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SCHOOL SCIENCE AND MATHEMATICS

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXI NO. 1 JANUARY, 1931 WHOLE NO. 264

SOME NEW YEAR RESOLUTIONS.

BY THE EDITOR FOR CHEMISTRY.

January 1st, 1930. I hereby solemnly resolve, as a teacher of chemistry that I will endeavor as much as possible to forget that I am supposed to be teaching chemistry and remember that I am really teaching boys and girls. While, perhaps, considering some few of the multitudinous facts of chemistry with them I will try my best to focus attention upon and arouse interest in the broad general relations rather than the petty details of the unit we are at work upon. I will try to discourage mere memorization and to encourage my pupils to learn so to master the essentials of the subject that they will be able to apply their learning in other situations of related nature. I will think up and set before them real or contrived situations in order that they may have practice in applying the lessons of the unit before passing on to other topics. From time to time I will contrive to bring again into use, in new situations, the more important lessons of the recent past in order that my pupils may fall into the habit of making use of their learning as occasion may require and that they may gain some assurance that they can so apply their knowledge.

When my administrative officers, from time to time, interrupt my work by demanding "marks" for my pupils I will endeavor to make use of the interruption to try to gauge the growth in power of my proteges since the last invasion of the office and I will seek to select wisely from the newer type testing instruments while holding fast to that which has been proven by much experience to be worthy.

Finally, I will seek to make such friendly personal con-

tacts with my pupils that they will unconsciously be influenced by my life not only to acquire the scientific habit of thought but to habitually choose the better way in all of life's contacts.—F. B. W.

A CHRISTMAS PRESENT TO THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INC.

Just before Christmas the Secretary of the Central Association of Science and Mathematics Teachers, Inc., received the following communication:

Dear Mr. Roecker:—You may cancel this as a Christmas gift to the Association.

Attached to the letter was a Journal debenture for $100.00 and the request that the donor's name be kept secret. Earlier in the year another debenture holder made a similar gift of a ten-dollar debenture. On behalf of the officers and members of the Association, the Board of Directors acknowledges receipt of these gifts and extends to the donors the heartfelt thanks of the Association. Such generosity encourages the Association to greater effort in the cause of education and better teaching.

A TEACHER'S RESEARCH PROBLEMS.

By HOMER W. LESOURD.

Several years ago in a talk to the faculty of a certain preparatory school, the speaker asserted that the school should keep no teacher on its faculty who was not actively engaged in some form of research work in addition to his teaching. This man who is well known in America because of his own contribution to scientific knowledge was apparently ignorant regarding teaching conditions in secondary schools. His statement, however, gives us something on which to meditate.

Just one hundred years ago Joseph Henry, while a teacher in Albany Academy, made his famous discoveries in electro-magnetism. Doubtless, there can be found today in secondary schools a few scientific investigators but they are working under obvious limitations of time and equipment.

Research is commonly defined as a continued, careful inquiry or investigation into a subject in order to discover

facts or principles. However, if the term is more broadly defined, it may properly be claimed that the ambitious science teacher who develops a new method for presenting some difficult concept or incorporate some new idea into apparatus with a view to improving the technique of teaching is engaged in valuable, creative research. It follows that the results of his efforts should be published in some form, and throughout its career, this magazine has welcomed the opportunity to serve as a forum to which original ideas may be brought for exchange. "If two men exchange two dollars each will have but one; but if they exchange two ideas each will then have two."

A GREAT SUCCESS.

The Thirtieth Convention of The Central Association of Science and Mathematics Teachers under the direction of President W. G. Gingery, Principal of the George Washington High School, Indianapolis, was held at the Lincoln High School in Milwaukee November 28 and 29, 1930. It was a meeting that will long be remembered by all who attended. Every session was packed with wholesome educational nourishment and stimulating mental viands. From Friday, 9:00 a. m. until 11:00 p. m. the time was occupied by lectures by the best scientific talent in the schools and colleges of the middle west, by exhibitions of the recent improvements in scientific apparatus, by book displays, and by reunions with old friends and meeting new ones. Saturday morning brought additional attractions—the marvels of starland, atomic wonders, and last minute developments in the field of education. Those who attended were doubly repaid; those who did not lost a real opportunity. Milwaukee and the Wisconsin teachers were gracious hosts. They made the convention more than just another annual meeting.

The reports of the Section meetings are published in this issue. A part of Miss Alice Hahn's paper from the Geography Section also appears this month. The remainder of her study and other addresses will be published in February and following issues. The 1931 meeting will be held in Chicago, November 27 and 28. Plan now to attend. Write to your section chairman at once stating your hobby. It may be just the thing for the next program.

THE PLACE OF PLEASURE IN STUDYING MATHEMATICS.

By Fletcher Durell,
Belleplain, N. J.

One day in the latter part of a summer vacation, a retired teacher of secondary school mathematics, whom we will call Z, was consulted by a relative of his about the school studies of the latter's nine-year-old daughter, called Mary. In the last school year Mary had been a pupil in the fourth grade of a certain public school. She was an imaginative child and had done particularly well in the subject of English. She had written creditable little stories and poems and was an inveterate reader.

In fact she had succeeded well in all her studies except arithmetic. She did not like this subject and her deficiency in it had been increased by certain absences on account of illness, particularly a rather long one at the end of the school year, during which the class for the first time had taken up the subject of long division.

Just before he came to consult Z, Mary's father by the use of simple tests had discovered that his young daughter not only knew nothing about the subject of long division, but that her knowledge of the elementary number facts (as to addition, substraction, etc.) was seriously defective. Mary was well aware of her deficiencies, and because of them was in a highly nervous state at the thought of going back to school in September.

What was to be done about the matter? Would it be the wisest course to have Mary attempt to do the full course in the fifth grade, meantime trying to make up her deficiencies in arithmetic in some way? Or would it be better to have her repeat the work of the fourth grade in arithmetic and at the same time go on in the fifth grade in other branches?

In his past experience as a teacher of high school mathematics, Z had met somewhat similar pedagogic problems and had devised methods which had succeeded with some of them. Perhaps he could adapt some one of these methods to meet Mary's case. Why not try? Would they send the child to him for a short lesson of about ten minutes each day for a few days? Mary's father gladly assented to the plan.

When Mary appeared the first time, she was in a nervous, shrinking state, and tears were brimming from her eyes and trickling down her cheeks. It was evident to Z that the first thing to be done was to remove from the child's mind the impression that arithmetical work was something strange and difficult. Probably the best way to do this would be to make her realize that some parts of arithmetic were easy, even a "cinch." So Z wrote for her on paper a few simple examples like the following: 11+7=, 28—6=, 31×7=, 693÷3=, etc. None of these it will be observed called for any carrying or borrowing.

Mary did all of the assigned examples with ease and correctly in about three minutes. Z then told her a short story of the kind she liked so well. His object in this was not so much to sugar-coat a pill as to link up her new pleasure and sense of achievement, which were evident by the changed expression on her face, with her other more customary joys.

This brief review of elementary number facts each time followed by a short story was repeated for three mornings. No attempt was made to cover all the prime number facts. The main object was to remove the child's inhibition against arithmetic and to create a cheerful and confident state of mind.

On the fourth morning the dreaded subject of long division was taken up. After explaining two or three very simple examples, all of which were included in the work afterward assigned, Mary was asked to perform the following divisions:

441÷21	462÷21	483÷21	504÷21	546÷21
588÷21	651÷21	672÷21	861÷21	882÷21

All of these she worked correctly in about three minutes without any help. So after the promised story had been told she was excused. It should be noted that in all the above examples the same divisor was used and that this was the easiest possible one that could be selected.

The next day the following examples were assigned:

651÷31	682÷31	713÷31	775÷31	868÷31
1116÷31	1147÷31	1178÷31	1302÷31	1333÷31

These Mary also worked in a short time but she needed a little help with the example whose dividend was 1116.

While she was working the later examples in the above list, Z happened to notice that Mary was using as an aid a numerical table which she had computed and put on a separate sheet of paper. On looking into the matter Z found that early in her work she had observed that the divisors in all of the examples were the same, viz: 31. She had then temporarily stopped working the assigned examples while she computed all the primary products of 31, as $1\times31=31$, $2\times31=62$, and so on up to $9\times31=279$, and arranged these products in a column on a separate sheet of paper. She then used this auxiliary table by taking from it products as needed and fitting each in its proper place. She thus was able to determine the successive figures in the various quotients in a short way.

So on her own initiative and by her own resourcefulness, she had devised an original piece of technique which might be used to cover the whole of the difficult subject of long division. This shows that the very easy examples which had been assigned her had not had a pauperizing or paralyzing effect on her mental processes, such as might naturally have been feared, but had had the contrary effect of arousing in her mind a natural growth process and a certain creative instinct.

It goes without saying that by this time, Mary no longer dreaded her morning lesson in arithmetic, but greeted each new set of examples with a confident smile and an evident anticipation of the pleasure to be derived from some new kind of achievement that lay before her.

After two more lessons of this kind in the simplest possible cases of long division the work was discontinued for certain unavoidable reasons. However she had shown such improvement in her work and such a change in her attitude that it was decided that when school opened she should try the fifth grade work in arithmetic as well as in other branches of study, with the understanding that if she should have trouble with her arithmetic at any time she should go to Z for help. As a matter of fact she came to him but once. This was in relation to work in long division where the divisors were numbers like 27 with the second figure large in comparison with the first.

A few weeks after school opened, Z when visiting Mary's home, saw her at work correcting with blue pencil a heap of papers in arithmetic. When asked why she was doing this, she said that the teacher had that day asked the three best pupils in the class to correct the papers of the rest of the class. Later still when asked how she was coming on in this subject she replied, "We're studying fractions now. I just love to work fractions." Casual test questions given her at different times during the school year showed that in all cases, she had a firm grasp of principles.

It is to be noted that in the above case no formal diagnostic tests or like pedagogic machinery were used, and that the small amount of preliminary remedial work was employed primarily to create a state of mind rather than to convey knowledge. Also the total amount of the child's time occupied in all the lessons did not exceed an hour, and the entire time spent by the teacher in actual instruction was less than ten minutes.

The numerical work assigned in these lessons was easy, but not in the sense that it meant a mere escape from hard and unpleasant work. The latter part of it related to a new and worthwhile topic. Also there was in the examples a certain progressiveness which pointed towards vistas of future progress. Again the small amount and easy nature of the formal number work involved left a large part of the child's mental energies free to be used in forming a clear idea of the nature and meaning of the new process being studied, in enjoying a novel sense of achievement, and even in developing some creative activity.

In other words the pleasure being experienced was not merely, as has been said, the negative one of release or escape from hard work; it was positive and constructive. It contained the seeds of future progress, the prophecy of growth to come.

ORIGINALS IN GEOMETRY.

We have said that previously to this incident Z had had certain pedagogic experiences which had suggested to him the method which he employed in dealing with little Mary's case.

For instance, when Z immediately after his graduation from college had begun to teach geometry as a college preparatory subject, the teaching of any original exercises in connection with the subject was a recent innovation. When he himself had prepared for college the textbook in geometry which he studied was Davies Legendre, in which there were no originals whatever. Such exercises when first introduced into books used in high schools were taken bodily from college textbooks, as for instance from those given as "riders" in Tod Hunter's Euclid. They were difficult, practically ungraded, and no technique had as yet been developed for teaching any kind of originals to pupils in the high school stage of development.

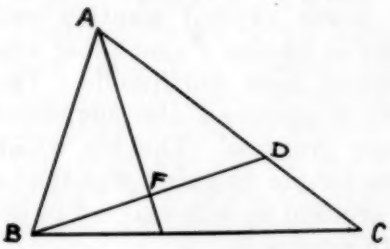
So far as the body of the class was concerned the first attempts to make such work a real part of the course was a failure. Few pupils made any vigorous attempt at the solution of these exercises. They looked on in wonder and admiration, while a few specially gifted students put their demonstrations on the board. So general was the inability of pupils to solve these originals, and so great this dislike of such work, that college entrance examinations in geometry at that time had to be so framed that it was possible for a pupil to enter college with knowledge of textbook theorems only and without solving any original exercise.

Many teachers of the subject, among whom was Z, realized that pupils who studied geometry without learning how to solve originals missed the most important benefit and the highest joy which the subject could bestow. Hence these teachers began to investigate and experiment with a view to obtaining a remedy.

In the course of his own particular experiments Z found, for instance, that the following exercise seemed to wake up the class and arouse an unusual amount of interest and that its solution was well within the scope of the average pupil.

The source of special interest in this exercise apparently lay in the fact that while the reasoning involved is very simple the use of extra lines besides those contained in the two congruent triangles themselves, to a certain

extent masked the solution and the extraction of the proof from among these surroundings gave to the beginner in this subject a thrill of adventure and a distinct sense of achievement. This sense of achievement was enhanced by the need to select from the various types of congruence in triangles, as *s.a.s.*, *a.s.a.*, *s.s.s.*, *h.a.*, *h.l.*, that particular case which applies here.



Given the △ ABC in which AF bisects ∠ BAC and BD ⊥ AF
Prove △ ABF ≅ △ AFD

As he continued his experimental investigations of the matter, Z found it desirable to simplify still further this early work. It was found best to have the first lesson consist entirely of exercises in proving triangles congruent by a single method, as *s.a.s.*, and on diagrams containing no extra lines whatever. Variety was obtained by changing the position and shape of figures, and varying the language and symbols by which hypothesis and conclusion were expressed. In fact we might say that the lesson consisted of a single exercise or theorem clothed in successive different garbs. To the pupil it was a fascinating game to unravel this one solution from so many different outward appearances.

Next, a similar lesson would be given consisting of exercises all based on the *a.s.a.* type of congruence. Then a third lesson consisting of these two methods mixed. And so on.

Practically all pupils learned to do this work well and rapidly, and all enjoyed it far more than the study of book theorems; though even that ordinarily rather dull and tedious work was irradiated by some of the spirit of exploration and adventure acquired while working the exercises.

From one point of view beginning work of the kind just described is so easy as scarcely to seem worthwhile.

But here again it is to be carefully noted that it involves much more than the negative deadening ease of escape from hard work. Among other values, it confers to all pupils, bright as well as dull, a many-sided, thorough grasp of the primary concepts of geometry. First principles such as the statement that all right angles are equal, or that things equal to the same thing are equal to each other, which at first sight had seemed so obvious as to be childish and not worth explicit mention and study, came to be understood as having a functional and instrumental value which made them worthwhile. The progressiveness in these sets of exercises also suggested and indicated vistas of future progress. The joy which the pupil felt in solving these simple exercises was thus a joy with a future in it. It aroused in him and set in action valuable natural growth processes.

Like methods were also devised by Z for solving verbal problems in Algebra and for teaching other topics in secondary school mathematics, and with like results.

As the work progressed, one clear evidence that such a method was not dwarfing and stunting the minds of the pupils was shown by the fact that some of the brighter ones began to ask for harder problems, that they might, by the solution of these, experience a greater thrill of achievement. Z often used to remark that no teacher has experienced the full joy of his profession till he has had a request like this.

That doing work of this kind is stimulating and not the reverse is also shown by the fact that pupils of all grades of ability went further and acquired a more thorough mastery than was the case when the old methods of drive and compulsion were used.

To mention the numerical results of College Board Entrance examinations is rather taboo in these days, but such results at least have a certain definiteness and are a rough first measure or index in evaluating methods. One year pupils in Z's department, not hand-picked in any way, turned in 339 College Board papers in algebra, geometry and trigonometry of which 332 were passing, over forty per cent were graded above 90, and 4 received a grade of 100.

What was of much more consequence was the change in the spirit and attitude of pupils in all their mental processes. This was shown in their increased alertness, independence, and vigor of thought as to work in other departments, and as to life as a whole.

Pleasure and Wisdom.

It requires no great amount of penetration, however, to perceive that the method of instruction which has been described, in its actual application calls for a considerable amount of wisdom and discretion on the part of teachers and administrators. If pupils are allowed and encouraged to study what they like, the likelihood arises that they will choose much that is superficial and not best for them in the long run; that their mental fiber will become soft and flabby instead of more robust. Objectively, also, the curriculum of study and the school organization may become chaotic and demoralized.

Evidently a certain balance is needed between what the pupil prefers and what, in the light of the past experience and the best judgment of his elders, he ought to study. In fact, if possible a certain fusion, and active co-operation of these two elements is desirable.

About two years ago, by the generosity of a member of the DuPont family, the Howard High School for colored boys and girls was built in Wilmington, Delaware, at a cost of over a million dollars. The building contains the latest and best equipment and appliances of every sort. Before the curriculum was constructed, the pupils were asked to state what studies they liked and preferred. Then the departments and courses of study were laid out largely with reference to the wishes thus expressed.

Evidently in this case, although the tastes and preferences of pupils were first convassed, the wisdom and experience of educational experts were afterward applied to the matter in hand. The object was to get a curriculum which was not only pleasing to the pupils but which would lead to worthwhile results both for the children and for society at large. In other words, an attempt was made to devise an harmonious and effective cooperation between the tastes and wishes of pupils and

the best available wisdom of their elders, to insure that pupils should enjoy their work, but also that this joy should contain the seeds of future growth and usefulness.

Is this balance between an effective blending and co-operation of these two elements always possible? The answer is that it is probably always possible if we make full use not only of our own intelligence but also of the large amount of technical pedagogical research work which has been done in recent years.

So many well-tested teaching devices are now available from which to choose, that it is more and more feasible to have pupils like their work, and at the same time to be sure that the work is fundamentally worthwhile as to its subject-matter, and systematic and progressive in its form and organization. So many kinds of system are at hand that it is practically always possible to select or by modification devise one such that its use shall not only not interfere with the pleasure of the pupil as a dominant factor, but shall help make that pleasure continuous and cumulative.

In carrying out such a program certain special devices are often available whose use will facilitate the general scheme and make it more effective. Thus a topic which the pupils particularly enjoy, such as graphs in algebra, is frequently analyzable into parts, and it is possible to place the parts at points where the interest might otherwise slacken. Those new type tests, such as completion exercises, in which pupils take especial delight can also be used to awaken interest when the work is in danger of losing its appeal. In a more general way, it is possible so to weave the abstract and concrete together as to give a pleasurable variety, and in other ways enhance the interest as well as keep it unbroken.

If there are spots of hard drudgery in a course of study, and it is not undesirable that there be such, it is possible to build up such a preceding momentum of interest, that the pupil will readily be carried across these effortful areas and yet realize to the full the benefits conferred by this kind of work.

If a method of instruction is used which is based on a consideration of individual differences in pupils, there is

room for much working out of special details and variations adapted to particular cases as a part of the plan under consideration and thus making the method more efficient as a whole.

In this matter of the further development of the science and art of the most effective combination of what the pupil enjoys and what will ultimately be the best for him, mathematics perhaps has an especial opportunity to perform a useful office. Because of its detachment from concrete entanglements, its definiteness, and the simplicity of its concepts, it seems particularly well fitted as a field in which to carry on experimental investigations along the lines which have been outlined.

Some Reasons Why.

Certain of the advantages connected with a wisely used joy-method of instruction have been mentioned more or less incidentally in the course of the preceding discussion. A few other such items will now be briefly stated.

The first of these relates to the matter of memory. Not only does this method of study ensure a thorough understanding of primary concepts and principles and in the end confer a more vital and creative grasp of the subject studied as a whole, but it also, as a part of all this, should result in an improved power to recall the facts and processes that have been learned. In recent years many tests have been given to high school pupils showing how little of the technique of arithmetic they retained. Many like tests have been given to freshmen in college revealing in like manner how imperfectly the elementary processes of algebra had found lodgment in their minds. The results of these tests have been widely published and commented upon. The prevailing opinion seems to be that the fundamental cause of the lack of retentiveness in these cases was the pupil's lack of real interest when such subject matter was first studied. Plainly if when first studying a subject the mind of the pupil can be put into a state of emotional white heat, a piece of technique dropped into it is apt to make a deep and permanent impression.

Again we have here an aid to vocational guidance.

For when pupils are working in the way under discussion they are making an unconscious but vital self-revelation of their tastes and aptitudes.

The method also supplies an impulse toward subsequent adult education. The joy-activities and spontaneous growth processes aroused, are of the kind which are apt to continue in operation after the pupil ceases his formal studies in school or college. They thus tend to make all life a continuous process of progress in thought and culture.

As to the various new-type kinds of education, so apt to become extreme and faddish, the method under discussion is fitted to extract, organize, and exploit the best that is in each of them.

So also while in some ways it calls for more effort and alertness on the part of the teacher, on the whole it makes the teacher's work easier and leads to deeper and more enduring satisfactions. For instance, it reduces formal, mechanical drill, and the use of diagnostic tests and remedial work to a minimum, and at the same time makes the application of such methods easier and more productive of results. Also the wear and tear of formal discipline diminishes and often disappears altogether.

It is a large step toward a real democracy in education; that is, toward a high type of co-operation of pupil, teacher, textbook, and in the end, also of parent and society. Hence it should be a valuable preparation for the best kind of business management and citizenship in general.

A brief mention may well be made at this point of a certain group of closely related social and cultural problems for which an early solution would be highly desirable and on which the preceding discussion throws some light.

Thus many publishers of newspapers make it their avowed policy to print what, as they say, the public wants and is willing to pay for, in spite of the fact this may be cheap, sensational, and even degrading and demoralizing. Social reformers, on the other hand, assert that such publishers should have a prime regard to what is ultimately educative and uplifting. The same con-

flict occurs in regard to the theater and the movies. How shall these two points of view be reconciled? Evidently any skill acquired in school work, of striking a balance between what the pupil thinks he wants and what is good for him should be of some aid in striking a like balance in the journalistic, amusement, and other like social fields.

In General.

The research department of the Vineland (N. J.) Training School for feeble-minded children has produced certain results of nation-wide, even of world-wide value. This was the first institution in the United States to use and elaborate the so-called Intelligence Tests. During the World War our army officers came here to develop the A Army Tests which afterward were put to such important use in selecting from the miscellaneous ranks of recruits those best fitted to be utilized as officers in the army or for other special services.

From Vineland the use of Intelligence Tests has also spread rapidly throughout practically the whole of our educational system and through many of our business organizations in an almost revolutionary way and with beneficial results whose end it is hard to foresee. The special advantage of a school like that at Vineland as a field for such investigation lies in the fact that in a mentality of low order the processes of development are slow and are so spread out that they can be examined more minutely and thus determined with greater accuracy. Mental growth which in a normal child occupies but a single year may here be elongated over as much as four or five years, and its successive stages may thus be more readily observed in detail. In the words of a leading educator who spent a considerable time at this school in studying the methods employed and the results obtained, the primitive mind when thus examined "whispers to us syllable by syllable the secrets of the soul's growth."

Hence it is worthwhile to note that the motto posted in large letters on the walls of the assembly room of the Vineland School is this: "Happiness first, then all the rest will follow." Thus in the very home of the formal Intelligence Test as a part of our educational machinery,

the joy of the pupil is put in the first place and by inference mechanical methods are made secondary.

Or if we go to the other and higher end of the scale of mental ability, we have the conclusion arrived at by Terman after his studies of genetic genius: "No matter how great a man's intelligence may be, he has to be interested to succeed in a great way."

So also we have the even more sweeping statement of Robert Louis Stevenson that "to miss the joy is to miss all."

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,
The University of Oklahoma, Norman, Okla.

We can always find a new hypothesis to fit a new fact. —*Poincaré.*

Accidental truth of a conclusion is no compensation for erroneous deduction.—*A. S. Eddington, "Space, Time and Gravitation."*

All science consists in pushing difficulties further back. —*Arthur Schuster, "Progress of Physics During 33 Years."*

That which distinguishes an argument from a play upon words is that the latter cannot be translated.—*Barrès, "On Life and Letters."*

The multiplicity of facts and writings is become so great that everything must now be reduced to extracts.—*Voltaire.*

It may be said, broadly, that science has simultaneously, and in equal measure, increased man's power and diminished his pride.—*Bertrand Russell, "Whither Mankind."*

Science advances in two ways, by the discovery of new facts, and by the discovery of mechanisms or systems which account for the facts already known. The outstanding landmarks in the progress of science have all been of the second kind.—*Sir J. J. Jeans, article on "Relativity," "Encyclopoedia Britannica," 14th edition.*

The crying need of the whole American people today is for better training in scientific methods of thought and a broader knowledge of scientific principles. If we had these we should be less a people of fads and cults and isms, less a prey to fakirs, mountebanks, and demagogues of all kinds.—*R. A. Millikan, "Why Study Physics."*

Science is teaching man to know and reverence truth, and to believe that only as far as he knows and loves it can he live worthily on earth, and vindicate the dignity of his spirit.—*Moses Harvey.*

FOUR UNITS TO ILLUSTRATE MOTIVATION IN THE TEACHING OF GEOGRAPHY: PART I.*

BY ALICE J. HAHN,

Proviso High School, Maywood, Ill.

The first unit, included in the list of four which are to appear in successive issues of the Journal, and which are to illustrate how the teaching of geography may be motivated, is one chosen, as are the others, from a course in Geography which I have been trying this year to work out at the Proviso High School in Maywood, Illinois. I decided to include the first unit because I thought it would help you better to understand how we approach the subject, and how we try to introduce it to the children.

As you will see, the first thing that we do is to outline the definition of geography. When I ask the children coming into my class for the first time what their conception of geography is, I invariably get such an answer as this: "Geography is the study of the earth and the people living upon it;" or—"Geography is the study of the products of various countries of the earth." Geography may be that, but it is also much more. In studying geography according to these definitions, there is nothing vital, nothing which particularly stimulates their thoughts in the way of problems, absolutely no *relationships* between the activity of man and his natural surroundings. Geography studied in this way is merely a bundle of facts to be learned or memorized, places to be located, and perhaps a few interesting things to be read. It is not as it should be, a science which leads them to compare, contrast, formulate conclusions, and deduct principles. It does not lead them to ask the question *"Why?"* Our first task then in the class room is to find out just what it is that we are to be studying—just what geography should come to mean. We learn that it is "the *adjustment* that man makes to his natural environmental conditions or the study of the relationship between the human activity and the natural surroundings. Man must fit himself into the elements of his natural surroundings over which he has little or no control, and his method of doing so must of course vary as his natural surroundings vary.

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*This paper was read before the Geography Section of The Central Association of Science and Mathematics Teachers, Milwaukee, Nov. 28, 1930.

We work out together different possible types of adjustments, and list also some of the elements of the natural environment which will cause man to change his way of living from place to place, outlining these in a way similar to that in your unit under points A and B. An analysis of this sort not only teaches the children to think clearly, but also leads them to ask such thought-provoking questions as these: "Why are most of the houses in Mesopotamia and Egypt built with flat roofs while most of our homes here have roofs that are sloping? Why are the railroad trains in Egypt equipped with windows of green colored glass? Why must chicken houses in Alaska be artificially lighted during several months of the year in order to have the chickens lay? Why are the flower beds in Buenos Aires set out generally on the north side of the house? Why, two years ago, when the University of Chicago called a professor to the Department of Geography from the University of Australia, was he not able to accept the call until January? Why . . . . ? They find that many of these answers may be found in the study of the natural environment and the way in which people are adjusting themselves to it. Thus, they find that in Mesopotamia and Egypt the lack of precipitation makes it unnecessary to have sloping roofs as we have here, and that this space may, therefore, be used by the inhabitants as a place to sleep. They learn that green glass in the train windows in Egypt is a protection to the eyes against the glare of the extreme sunlight reflected by the desert sands; that in Alaska, the long nights make it necessary to stimulate the hens to laying by making them think at least that it is day; that in Buenos Aires the sun never shines on the south side of the house, and that in Australia the school-year doesn't end until January, when the summer vacation begins.

The children must not be led to believe, however, that Geography will explain everything. We must beware of generalizations. Geography is *not* the solution for every problem, for there are other factors that enter in also. When people migrate to a new environment, there may be a choice of several ways in which they might adjust themselves. Which of these choices they will make will depend somewhat on their social heritage, and the traditions of their race.

Then, too, it often happens that the best possible adjustment is *not* made; that the people are carrying on activities which may be better suited to a different combination of elements. The natural environment is perhaps the sole factor in determining the *possibilities* of choice in each place, but we must always remember that it very often does not explain altogether the particular choice which is made. Our problem in Geography then is to try to single out the human activities and the elements of the natural environment and show how the two are related. In order to give the children practice in doing this, their first list of references is assigned to them with a definite end in view. From the list of books printed in the first Unit, they are told to find as many examples as they can showing the relationship between the physical environment and the human activity, to be written out as are those on the guide sheet following. On the one side they are to list only the human activity; on the other, the elements of the natural environment which have helped to make the adjustment what it is. The arrow indicates the *relationship* between the two. In this way the children get an idea of what is really wanted at the very outset; they are trained to read for a definite purpose; and they like the idea of finding and discovering things for themselves.

Very often people will argue the question: But why teach Geography as such at all? Aren't there other subjects into which Geography might be incorporated so that its teaching apart from them is unnecessary? As a second part to our first unit then, which serves after all, just as an introduction to the whole course, we try to answer that question for them. What is the scope of Geography, and what, if anything, is its destinctive contribution? In the first place we find that Geography gives us a *leisure interest* which can be had in no other way. It gives children new insight into the things about them. When they see signs of a human activity either at home or in travel, they immediately begin to ask, "*Why* is this so? *Why* are the people doing this particular thing here; why do they work, live and react as they do?" Their surroundings take on for them a new meaning, and in travel instead of sleeping away their time or wondering how they are to spend the hours on the train between their point of departure and their destination, they will find

the whole trip a wonder-book of fascination. As we have said before, their questions may not be fully answered for them by the natural environment, but at least it will help to explain a great many things. Knowing the natural environment, they will nod their heads triumphantly as much as to say, "Exactly what I expected. Isn't it nice to be able to understand?!...." The same principle might be applied to our reading. Geography helps us to read so much more intelligently.

Our second point in favor of teaching Geography as such is that it helps us in making *economic adjustments*, which are, of course, all important for the success of any people or any nation, either as a whole or individually. If we know the natural environment, we shall know how best to fit ourselves into it; if we do not, we are likely to fail or learn only by the old wasteful method of trial and error. When the west was first being opened up for settlement, many of our Illinois and Iowa farmers trekked onward to Oklahoma and Kansas, thinking there to plant still larger corn fields, and reap still larger harvests. Year after year they were disappointed, year after year they failed, until finally they realized that the natural environment was different; that the type of corn grown here could not successfully be grown on the amount of rainfall in the western states; and that the fields sown there in wheat yielded so much more bountifully than those planted in corn. They learned, yes. But they learned through bitter experience and failure.

Not only do we find a knowledge of the natural environment valuable in agriculture. It is necessary in almost any type of adjustment we wish to make. Several years ago, many people lost a great deal of money in the Florida real estate boom, and much of it because they did not know the conditions. They thought that the natural environment of the entire state was the same as that found around Palm Beach. Even cities have failed because their founders did not fully understand the geographic principles which govern or help to govern their success and their growth. Columbia City, Oregon, is a good example. We find in Unit IV, the geographic principle that "Cities tend to grow up at junctions of large rivers where traffic coming upstream is

divided, a part going up each stream, and where in many cases commodities coming down the tributary streams are transferred to boats operating on the main river." Columbia City was located at the junction of the Columbia and Williamette Rivers, but the founders did not take into consideration that traffic coming upstream did *not* have to be divided here, since the Williamette river is navigable past this point. And so it was that Portland eventually became the important metropolis while Columbia City, contrary to the expectation of its founders, dwindled into nothingness.

As a third point, Geography also helps us in making *civic adjustments,* although we cannot say that it is alone in this field. There are other subjects which contribute quite as much, although perhaps in a different way.

One of the most vital contributions of Geography to my mind is that of helping us to understand the adjustments of other people, thus contributing to international good will. If national jealousies, prejudices, and distrusts are to be lost in a world of larger vision, cooperation, mutual sympathy, and understanding, it is the teachers, perhaps more than any other one body of workers, who must help to bring this about. I like particularly Peattie's attitude on the subject, and quote from his "College Geography" on the second page of this unit:

"If one understands how a people came to a state of culture and why they think, act, and have their being as they do, one comes almost invariably to sympathize with their condition. A sympathetic understanding as between the rich farmer of Iowa and the less fortunate mountaineers of North Carolina may lead to cooperation of the finest type .... Prejudice is usually ignorance." And again, "There are four correctives of world population: war, pestilence, famine, and the regulation of life to fit the conditions of environment."

That last sentence seems to me particularly effective: "There are four correctives of world population: war, pestilence, famine, and the regulation of life to fit the conditions of environment." If more people would rightfully understand its meaning, I think many of our world problems would soon solve themselves.

Unit I: The Definition and Scope of Geography—

I. The Definition of Geography

Geography is the study of the *adjustment* that man makes to his *natural environmental conditions*, or the study of the *relationship* between the human activity and the natural surroundings.

A. Some types of human adjustment

1. Agricultural
2. Pastoral
3. Besticultural (Hunting and fishing)
4. Nemoricultural (Forestry)
5. Commercial
6. Manufactural
7. Saxicultural (Mining)
8. Recreational
9. Governmental
10. Social

B. Some elements of the natural environment to which man must adjust himself.

1. The earth as a planet
2. The variability in length of day and night from place to place and from time to time in the same place
3. Land forms and topography
4. Water bodies
   a. Oceans
   b. Inland water bodies
5. Soils
6. Minerals
7. Climate
   a. Temperature
   b. Rainfall (Precipitation)
   c. Pressure and winds

C. The study of the *relationship* between the two.

Our big problem is to see just how the first of these is related to the second—or in other words to see what people do, and how they live, and in so far as possible, find out *why* they live and act as they do, where they do. Geography alone cannot give us the complete reason for each adjustment. There are other things that help to determine just what the human activity or adjustment will be, such as social heritage, tradition, and race. But the natural environment is perhaps the sole factor in determining the possibilities of choice in each particular place. Our problem then will be to see just how those various activities are related to the natural environment, remembering that the natural environment may not have been the sole reason for that particular choice.

II. The Scope and Contribution of Geography

A. Leisure Interest (in traveling; in reading)

B. Economic Adjustment
Lack of knowledge of conditions has brought failure.

1. In agriculture
   Corn in Kansas
2. In purchasing real estate
   Florida
3. In choosing sites for towns
   Columbia City, Oregon

C. Civic Adjustment

Develops habit and attitudes of thought and ability that will help us in making better personal and social adjustments to the environment.

D. Contributes to international good will by helping us to understand adjustments of other people

"If one understands how a people came to a state of culture and why they think, act, and have their being as they do, one comes almost invariably to sympathize with their condition. A sympathetic understanding as between the rich farmer of Iowa and the less fortunate mountaineers of North Carolina may lead to co-operation of the finest type . . . . Prejudice is usually ignorance." And again, "There are four correctives of world population: war, pestilence, famine, and *the regulation of life to fit the conditions of environment.*" (Peattie)

Readings

1. Introduction to Econ. Geog., Jones & Whittlesey, Vol. I, pp. 3-4.
2. College Geog., Peattie, pp. 1-8.
3. Business Geog., Huntington & Williams, pp. 1-4.
4. Nature and Man in America, Shaler, pp. 147-173.
5. New Physical Geog., Tarr & von Engeln, pp. 577-605.
6. Geog. (Physical-Econ.-Regional), Chamberlain, pp. 1-17.

From the above readings write out to hand in all the examples you can find of geographic facts illustrating the principle of relationships between the physical environment and human activity. Write your relationships, placing the human activity in one column and the elements of the natural environment to which that activity is related in another. The following are examples:

HUMAN ACTIVITY	NATURAL ENVIRONMENT
1. Less than 5% of the area of Norway is cultivated.	1. High and rugged mountains cover most of area.
2. Most of the homes in Alaska are built along the S. E. coast.	1. Winter mild for latitude. 2. Harbors ice-free. 3. Warm ocean winds. 4. Lower slopes well forested.
3. Along the S. E. coast of Alaska the people wear oil-skin hats, slickers, and rubber boots when they tramp.	1. Rains more than two-thirds of days in year. 2. Walrus caught off-shore.
4. Agriculture is not greatly developed along the S. E. coast of Alaska.	1. Very little lowland. 2. Cool summers. 3. Precipitation heavy. 4. Much cloudiness. 5. Heavily forested.
5. Agriculture is fairly well developed in the Tanana Valley of Inner Alaska.	1. Fertile soil; largest body of good soil in Alaska. 2. Long summer sunlight. 3. Much of rainfall in growing season. 4. Moisture from ice beneath.
6. Corn is produced very extensively in Illinois.	1. Average rainfall from 30-40 inches; mostly thundershower type in summer. 2. Five months growing season. 3. Fertile soil. 4. Average summer temperature above 70°. 5. Level plains areas.

7. Chicago is the greatest railroad center in the world.	1. Situated at the southern tip of lower Michigan. 2. Situated in level plains area. 3. Center of rich farming area. 4. Easy access to coal, iron, copper, and lumber.
8. Wheat is produced by dry-farming in eastern Washington.	1. Less than 10 inches of rainfall per year.

REPORT ON THE BIOLOGY CLUB OF THE LITTLE FALLS HIGH SCHOOL.

By MRS. EMILY EVELETH SNYDER,
Little Falls High School, Little Falls, N. Y.

The Biology Club of the Little Falls High School was started in December 1928. As it is the only club primarily intended for freshmen, the program of the year is varied, and no attempt is made at difficult scientific work.

At the beginning of each term, a get-acquainted party is held to which all the entering freshmen who have any idea of joining the club are invited. In the fall this party takes the form of a hike and outdoor meal. At mid-terms an informal Saturday afternoon dance is held. The dues are nominal, ten cents a term and only very small assessments are made for extra things.

The club has a constitution which provides for the usual officers and specifies that every fifteen persons or major portion thereof in a biology class is entitled to a member of the executive committee. The representation for members who have finished biology is based on the same numbers.

Contests which are scored on the point system are run throughout the year on such subjects as: posters showing pictures to illustrate adaptation of structure to function; posters of labels showing compliance with the Pure Food and Drug Act, the presence of narcotics, et cetera; and compositions on conservation and allied subjects. The first prize is a year's subscription to "Nature Magazine."

At some of our meetings we have been fortunate enough to have had some excellent talks. For example, a district health officer gave a very understandable talk on communicable diseases. One of the best authorities on milk in the state talked on that subject. Also the high school prin-

cipal, a former biology teacher, gave his personal experiences fighting pine blister.

The club has its column in the school paper headed by its own insignia, BiologY. A club member is appointed each year as a staff reporter.

Last year the club presented two bits of entertainment in assembly periods. At Christmas time, it put on a humorous skit purporting to be a preview of a talking picture which was to be shown in the Bugville Theatre.

Later in the year, using Skinner's *Myths and Legends of Flowers* for material, members wrote and produced a fantasy called "The Garden of Myths." Panels of wall board were painted to represent different plants from behind which students representing the spirits of these plants came to tell myths concerning themselves to a boy and girl in the garden. The Spirit of the Poplar related a Grecian myth; the Spirit of the Rose, a Roumanian version; the Spirits of Indian Corn and Oswego Tea gave their Indian origins, while the Spirit of the Cotton told a fairy tale about herself. Older students of the Dramatic Club helped with the rehearsals.

The club meets the first Thursday in each month. Movies from the State Department of Health are scheduled for the December meeting.

Primarily a freshman organization, it is surprising that the older members have stayed in the club. The original membership of around forty has increased to eighty-one.

Aside from the arranged activities, the club offers through its offices and committees a chance to develop leadership. Through the subject matter of its activities and the fact that it meets in the biology room, the contact of the older students with the subject of biology is maintained.

CABBAGES IN THE CLASSROOM.

This is the title of a leaflet which was prepared by Dr. Ralph C. Benedict in connection with a study of cabbage types which has been carried on at the Brooklyn Botanic Garden during 1929 and 1930, largely with the idea of making these common vegetables more familiar and usable in teaching. Living material of upwards of thirty kinds is being grown in the experimental plot. Teachers who are interested may secure copies of the leaflet by addressing Dr. Benedict, Brooklyn Botanic Garden, Brooklyn, N. Y., or the Secretary.

THE RECITATION IN A SCIENCE TYPE SUBJECT.

By VERGIL C. LOHR AND CLIFFORD HOLLEY,
University of Chicago.

The aims to be accomplished in the teaching of any course determine the methods to be employed. Education is a process of adjustments to natural situations found in the life of the individual. As one author has stated recently " . . . . . that process of individual adjustments to the world, which we call 'education,' and which are the objectives of teaching, are always either *attitudes* or *special abilities* or *skills*. We shall think of attitudes as being always *attitudes of understanding*, where reflection and rationalization have been involved—found typically in the field of the sciences; or attitudes of *appreciation*, where the acceptance of values has taken place . . . "[1].

For several years the authors have been working with pupils in physics in the University High School and Junior College of the University of Chicago in an effort to formulate some technique for accomplishing these aims. Perfection of technique has probably not even been approached, yet there has been accumulating a vast amount of evidence which points quite clearly to certain desirable features in the conduct of courses at these levels. This article aims to present some evidence along one line of procedure.

The adjustment of the individual to his physical surroundings involves mastery of the units of learning in the physical world. Consequently the courses in physics have been organized into "units of instruction," the same units being used for the work in both high school and junior college classes, but with a greater amount of material included for the higher level. The entire field of elementary physics is covered by the authors in eleven of these units. In each unit we are concerned with a proper student adjustment toward, and assimilation of a comparatively few fundamental ideas, which lead to a complete understanding of the unit.

In current texts the field of physics is covered in from twenty-one to fifty-five chapters. The subject of sound, for example, is treated in from two to five chapters, but

[1] H. C. Morrison, "The Practice of Teaching in the Secondary School," p. 21, University of Chicago Press, 1927.

when the student has studied the five chapters the most that we can hope for him is that he has acquired an appreciation of the nature of sound. The real unit of learning then is "The Nature of Sound," and the chapters are merely teaching topics.

The first unit in the courses as given by the authors is called "The Molecular Nature of Matter." In this unit the characteristics of matter are studied in the solid, liquid and gaseous states. A large amount of material is used, many fundamental laws are encountered, and numerous phenomena observed. When all the ideas are assimilated they contribute to but four fundamental understandings, namely, (1) matter is composed of molecules, (2) molecules are in motion, (3) there are spaces between the molecules, and (4) molecules exerf force on each other.

During the study of the unit the criterion used in any assignment is its contribution to an understanding of the nature of matter. Boyle's Law, for example, is studied not as an end in itself, but rather as a means to an end; for through an understanding of this law the proper concept of the effect of molecular motions in gases may be formed. Hooke's Law and the study of elasticity are studied because they contribute to an understanding of the nature of the forces existing among the molecules of solid matter. Capillarity and surface tension contribute to an understanding of the forces between the molecules of a liquid, and between the molecules of a liquid and the molecules of a solid.

The four fundamental understandings, fully mastered, make it possible for the student to explain numerous phenomena, even though they were not considered during the assimilation of the unit, and contribute largely to his attitude of appreciation of the world about him.

When the pupils have acquired an understanding of the nature of matter through a study of the assimilative material, or have an understanding of any other unit of instruction, the time has arrived for the recitation in this plan of teaching.

One of the most neglected steps in the learning process arises from a lack of pupil opportunity for complete expression. The teacher has only to remember his own ed-

ucational experience to recall that many times his ideas about fundamental concepts had not crystallized until he found himself obliged to organize these ideas before presenting them to others. What teacher did not learn more about his subject in his first year of teaching than during any other year?

The testimony of scores of students is that, to their amazement, they are unable to express certain ideas which have been obtained from text books, or from class discussion, and which have been taken for granted as being clear. These same students have not been backward in expressing their delight in having been required to get these concepts clarified by organization and expression. "Half learning," the time wasting monster of our educational system, is unknown when adequate opportunity is given the student for expression.

The student who "knows but just can't express it" is deceiving himself and needs carefully to re-assimilate and reorganize his ideas in such a way that he can express them convincingly. The recitation, if properly conceived and executed, takes care of this phase of learning. The ordinary question and answer type of class room procedure must not be confused with recitation as here conceived. That procedure may be found advantageous in determining whether ideas have been properly approached or properly assimilated, and may be used to guide the student in thought processes, which will ultimately lead to mastery, but in no sense is it to be regarded as recitation.

For the recitation in a unit of the science type the student selects a topic from a list suggested by the teacher, or one that he may suggest to the teacher, upon which he desires to make his recitation. Such a topic must be comprehensive enough to include the fundamental understandings of the unit. Some topics for the unit "The Molecular Nature of Matter" might be: *The Similarities of Solid, Liquid, and Gaseous Matter; Differences in Solid, Liquid, and Gaseous Matter; Dry Farming; The Nature of Solid and Liquid Matter as Revealed Through Capillarity; The Nature of Solid Matter as Revealed Through Elasticity; How I Look Upon Gaseous Matter.*

Let it be understood that the recitation is not intended

as a test of the pupil's understanding, although a satisfactory recitation cannot be given without understanding. It is used to cause the pupil to arrange the material of learning in logical form, to enable him to separate the essential from the non-essential, and to show him that all the details of the assimilative material of the unit have focused upon but a few fundamental concepts. When the pupil has learned to see the unit in this light, and has seen the field of physics as consisting of perhaps a dozen units, he will carry away an intelligent understanding of, and attitude toward the subject of physics, or of any other course so organized.

Ideally the student is given an opportunity to organize his recitation and make any notes needed in the form of a brief outline. He then comes before the class, which, with the instructor, constitutes his audience, to present his recitation. The assumption is that he is talking to a group entirely ignorant of the subject matter under discussion, and his task is to present the material in a clear, convincing and intelligent manner. He may use charts and demonstrations as he may choose, but is not permitted to read his material from a prepared paper.

The authors have heard repeatedly in their classes such floor talks varying in length from five to forty-five minutes, which held the attention of the class perfectly, and which, by contrast in many cases, made the teacher uncomfortably conscious of his own limitation in organization and public speaking.

In each of the units the opportunity for expression must be given to all members of the class. In large sections the time element makes it impossible to give each pupil an opportunity for an oral "floor talk." However, some can be assigned oral recitations on a given unit, while others prepare written recitations, and in the course of a year each individual has several chances to speak from the floor. The authors have been amazed at the high grade response that has come in the case of written recitations. We little suspect what our students can really do until they are given a chance. The instructor must impress upon the pupil the necessity of selecting a topic, which used as a basis, will enable him to present the fundamental ideas

involved in the unit in such a clear, logical and sequential fashion, that any one entirely unfamiliar with the material can comprehend it fully.

The ingenuity that the students have manifested in putting the ideas across have been illuminating. On one occasion the instructor suggested that the student assume that he was writing a text book and was presenting the unit as he would have liked to have had it presented to him. Many of these student productions could profitably replace the sections dealing with this material of the unit in many of the available texts. The plans of presentation adopted by the students in their written productions have varied from straight, dignified diction to "Fables in Slang" that out-Ade George Ade himself. The dramatic instinct is ever present, and frequently the unit is expressed in dramatic form. The radio announcer has a splendid opportunity to broadcast ideas, and his place is frequently usurped. Letters to "kid" brothers, or other "dumb bell" members of the family are frequent. As an example of one particular setting for the discussion in which the pupil desired to organize and express the ideas involved in the unit "The Nature of Sound" and for which he had selected the topic "The Production of Music" we quote the opening paragraph.

"I had just returned from a most glorious concert given by the Chicago Civic Orchestra. Seldom had I passed through such delightful emotional experiences, and yet when it was over I was probably the most unhappy mortal on the face of the earth, for I realized that I had not the slightest idea as to how those tone effects were produced by the musicians on the various instruments, or why those tones had such peculiar effects upon me and upon others. My doctor friend, noting my state of mind and learning the cause, invited me to his club, where over cigars and coffee the following conversation took place."

Then followed a dialogue in which questions and answers covered the ideas involved in the production, transmission and reception of sound; the fundamentals of tone production in instruments of the string, air column and percussion type; the means of controlling loudness, pitch and quality; the physical basis of music and its psychological aspects. The written paper was some 3500 words in length.

Obviously it is impossible in such an article as this to give an idea of all the schemes, or a complete sampling of

such productions. The play given below is a type of work that can be secured from students at this level.

Differences Between Solids, Liquids and Gases

ONE ACT PLAY.

Cast of Characters

Sadie the Solid—A decidedly lazy, slow molecule.

Lizzie the Liquid—Quite an indifferent kind of matter with neither slow nor fast movements, but a very learned molecule.

Gertie the Gas—A very rapid, nervous molecule.

Scene.

A small glass of water with a section of the inside of the glass greatly magnified so that a glass molecule, a water molecule, and an air molecule are visible.

The Play Proper.

Gertie the Gas (Moving continually, first in one direction, then in another): I wish that I didn't have to come into these horrible places. I suppose that it will always be my luck to leave my own kind of matter and come into other kinds. We are such a queer family in that respect. Any one of us may leave the family fold at any moment.

Lizzie the Liquid (Moving in a much slower manner, and continually bumping into her neighbors): That is because you do not have great attraction for your brothers and sisters. Scientists call the attraction of like molecules *cohesion.* You see, we have quite a lot of family attraction, or cohesion, and my temperature has to be changed in order to make me move fast enough to leave the surface.

Sadie the Solid (Moving very slowly, rather in the manner of a pendulum): Our family is so closely connected that we can hardly move. That is the reason that I move so slowly. In comparison with other kinds of matter there have been very few black sheep who have found it necessary to flee from the family. I do hate to brag, but we have much more brotherly love than any of you.

Lizzie: Well, I dare say, you may have greater cohesive forces, but what about your adhesive forces?

Sadie: Adhesive forces?

Lizzie: Oh, I forgot that you wouldn't know about *adhesion.* That is the ability of unlike molecules to stick to each other. You see, just as I cling to the glass.

Sadie (Hesitating): Well—no—er, yes, we too have the ability to stick to other materials. Is that also why Gertie is sticking to us glass molecules?

Gertie: That's exactly the reason. We gas molecules rank first in adhesion.

Sadie: Well now, certain solids, namely, lead and gold, have been known to mix even though at only room temperature. Why is that true, Lizzie?

Lizzie: You have spaces between yourselves. That's why. But you haven't such great spaces, so it is hard to tell when diffusion takes place in solid materials. You see, the molecules of one substance try, in their moving, to get in between the molecules of the other substance. For instance, if you put some red water in the bottom of a glass jar and then some blue water in the top and leave the whole for a few days you will find that the two kinds of water have mixed. In other words they have diffused.

Gertie: Say, talk about large spaces between your molecules. Well, look at the spaces between us. Gas molecules are far apart and gases diffuse very easily.

Lizzie: I know that you mix much more readily than we do, but liquids still hold one thing which other forms of matter do not, namely, *surface tension.*

Sadie and Gertie: Surface tension?

Lizzie: Surface tension is the property of every liquid by virtue of which it tries to make its exposed surface as small as possible. That is partly the reason why liquids rise or fall in capillary, or small, tubes when these tubes are placed in a vessel containing the liquid. You see, the adhesion towards the glass makes the edges go up, if adhesion is greater than cohesion, or down, if the cohesion is greater than adhesion. The molecules try to undo the effect due to the net result of adhesion and cohesion, and the result is a small curve.

Gertie: I also rise in capillary tubes; in fact, I can alter my shape or volume in no time at all. I can fill any space, no matter how large. If some one would take a pint of air and pump half of it out there would still be a pint of air because the molecules spread out and fill the space. But I must confess that I don't have anything to do with surface tension as you call it.

Sadie: I don't have to be bothered with either surface tension or changing volume. Thank goodness for that. Why, someone would have to be drastic in order to alter my shape, and I couldn't rise in a capillary tube to save my life!

Lizzie: I say, there is just one more thing that I would like to talk about before we leave each other. That deals with the spacing of molecules, too. Have either of you heard of *elasticity?* I have elasticity, or so scientists say, because when a force is applied to me I can squeeze into a smaller space, and when the force is removed I can come back to my original volume. You see, it is because my molecules don't like to be either too far apart or too close together, so after the deforming force is removed they readjust themselves again to their former spaces.

Gertie: Why, that's true with me also. Somebody, I forget who, said that the pressure of a gas is inversely proportional to its volume. I wonder why.

Lizzie: That was Boyle. It is true because as the molecules are confined to a smaller volume their molecular spacing is becoming more cramped, and more are hitting per second on each unit of area of the confining vessel. You have the greatest elasticity of all of us because you can be condensed greatly, and can readily come back to your original volume.

Sadie: Well, I have elasticity too. But of course, I can't boast of such great elastic limits as either of you. Solids may be stretched up to a certain point, but after that point the molecules readjust themselves and the material will not come back to its former size. It takes a greater force to pull us apart because of our great cohesive qualities.

Lizzie: Then you have greater *tenacity* than either Gertie or I have, because it takes more force to pull you apart than it takes for us. However, liquid molecules have more tenacity than gas molecules.

Sadie: Well, thank goodness, I excel in one or two ways. My cohesive forces are greater than either of yours, and consequently my tenacity is greater. Well, I must be moving on. Goodbye. (She moves slowly away.)

Gertie: My, what a slow moving person! Humph! Excel, indeed. Look at me. I never do things in a half way measure. I excel in most things. Indeed, I excel in everything but cohesion and tenacity. Perhaps some day you may have the delightful privilege of becoming steam and thereby know the joys of being a gas. Goodbye, my dear. (Gertie bounds away rapidly.)

Lizzie (Sadly): Well, I guess I'm just nobody. I do things in only a half way measure. (Brightening up.) At least, I have surface tension. Praise be my lucky stars for that. (She too, vanishes at a moderate speed.)

A NEW CENTRIPETAL FORCE APPARATUS.

By GLENN M. HOBBS, PH. D.*

The apparatus utilizes a method which has been used for years, namely, that of measuring the centripetal force developed by a mass moving in a circle by balancing this force at a critical speed against the pull of gravity on a given weight mounted on a vertical shaft. However, the particular difficulty with the method always has been the large friction factor in the two sliding weights. On account of this, errors from five to ten per cent between the observed critical speed and that calculated from the simple formula have been the ruling errors in the results.

Another factor which has been a potential source of trouble is the fact that the rotating weights used were comparatively small so that a very high speed was necessary in order to raise the fixed weight. This factor brought into the experiment a real element of danger in that the breaking of the string holding the revolving weight might easily result in the weight being hurled across the room with the strong probability of striking and injuring someone in its flight. This apparatus has been designed with the idea of correcting these two elemental errors in the apparatus so that full advantage can be taken of an otherwise ideal set-up.

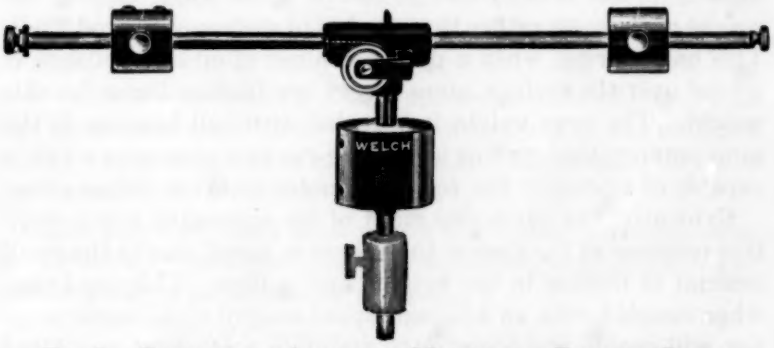

FIG. 1. CENTRIPETAL APPARATUS MOUNTED IN ROTATOR CHUCK.

The supports for the rotating weights are two horizontal rods branched from the center shaft, as shown in Fig. 1. The weight on one side is designed to be stationary, being clamped at the same distance from the center of rotation as the other revolving weight so as to counterbalance it. This second weight is free to

*W. M. Welch Scientific Co., Chicago.

move on its supporting rod and is attached by braided fishline to the center weight to be lifted. This revolving weight is made about one-third the center weight so that, as will be noted from the results obtained, a speed of only a little over two revolutions per second is necessary to raise the center weight. This is not in any sense a dangerous speed and no fear need be felt by the instructors or students that the revolving mass will get away from its moorings. To make the assurance doubly sure, stop screws are put on the ends of the rods which carry the revolving weight and its counterpoise. These screws will hold the weight in position even if the string does break.

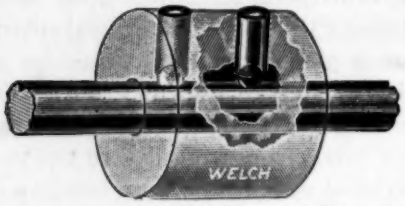

FIG. 2. SLIDING HORIZONTAL WEIGHT CUT AWAY TO SHOW BALL-BEARING CONSTRUCTION.

The other improvement is more fundamental and is the particular feature which contributes so much to the success of the experiment. The rod on which the moving weight slides is grooved quite deeply on its upper side, as shown in Fig. 2, and the weight itself has holes bored through vertically from its upper surface to the center hole. Balls of the proper size, placed in these holes and held by springs and by screw plugs, support the weight of the mass rather than the broad surface of the rod itself. This ball bearing, when a proper amount of oil and graphite is spread over the surface, gives a very low friction factor for this weight. The large weight is provided with ball-bearings in the same manner, thus making a very free-running apparatus which is capable of especially fine results, as noted from the values given.

Evidently, the particular merit of the apparatus is the sensitive response of the system to changes in speed, due to the small amount of friction in the weights and pulleys. This condition, when coupled with an adequate speed control of the motor rotator, will enable one operator to maintain a constant speed and thus hold the two weights at a definite point in perfect equilibrium for a long enough time to count the speed of the rotation producing this equilibrium. To make this control as delicate as possible a full ball-bearing motor rotator should be used. By controlling the speed with any type of brake on the leather friction wheel while the motor rotator is running, good results are easily possible. With very few trials sufficient technique

can be established by any operator to hold the speed at practically a constant value over several minutes, at least long enough to count a hundred revolutions by means of a speed counter attached to the shaft of the rotator.

The calculations for the experiment are simple and no elaboration of the theory is necessary in this article. The standard equation for motion in a circle is

$$f = \frac{mS^2}{R} = m\omega^2 R = m(2\pi N)^2 R$$

in which f is the force in dynes produced by the rotating mass m, ω is the angular velocity in radians per second, equal to 2π times N the number of revolutions per second, and R is the mean radius of rotation of the mass m. The centripetal force f is adjusted in the experiment exactly to balance the force of gravity Mg acting on the central mass M. Therefore we can equate these two factors.

$$m\ (2\pi N)^2 R = Mg$$

Solving for N we have

$$N = \frac{1}{2\pi}\sqrt{\frac{Mg}{mR}}$$

The calculated value for N should be compared with the observed value obtained by averaging the times of, say, four runs of 100 revolutions each of the mass m, while the masses m and M are held in equilibrium.

A series of observations with a maximum error of .5 per cent and an average error for seven trials of .2 per cent was obtained by the writer without the elimination of a single trial. Some of these results are given herewith.

In my judgment there is no type of centripetal force apparatus on the market which is so direct in its theoretical application and none capable of as high order of accuracy.

A NEW CENTRIPETAL FORCE APPARATUS.

Sample Observations.

Trial 3. $m = 215$ *g.* $M = 672$ *g.* $R = 15$ *cm.*
Observed times of 100 rev. = 43.8, 44.1, 43.9, 44.1. *av.* 43.83.

$T = .4383$. $N = \frac{1}{T} = 2.2815$ R. P. S.

$$N\ (calc) = \frac{1}{2\pi}\sqrt{\frac{672 \times 980}{215 \times 15}} = 2.2745$$

Error .3%

Trial 5. $m = 215$ *g.* $M = 672$ *g.* $R = 16.42$ *cm.*
Observed times of 100 rev. = 45.7, 46.3, 46.2, 46.0. *av.* 46.05
T = .4605 N (obs) = 2.171 R. P. S.
N (calc) = 2.169 R. P. S.

Error .1%

Trial 6. $m = 215$ *g.* $M = 672$ *g.* $R = 13.5$ *cm.*
Observed times of 100 rev. = 41.4, 41.8, 41. 8, 41.8. *av.* 41.7
T = .4170 N (obs) = 2.398
N (calc) = 2.3975

Error .02%

SPEED IN READING.

Six words per second, or about four and one-half hours for a standard size book, is good average reading speed, and most people can aspire to reach this seemingly extraordinary rapidity, according to Dr. R. S. Woodworth of Columbia University. Twelve to fifteen years of age is the critical period when a person is likely to form his tastes in reading. But any one can improve these tastes and can speed up his reading time as well, if he will attack the problem seriously. Interest increases speed in reading, as we notice when we turn from a serious book to an exciting novel. A reader who wishes to read serious books with speed and ease should ask himself questions which he wants answered by the book. The fast reader hurries to answer questions which have arisen in his mind, while the slow, dawdling reader is passive, not looking for anything, and so has no eagerness to press forward.

The brain, not the eye, determines the speed of reading. The eye cannot move steadily but must move in a series of jerks, with pauses between. These pauses are needed to see the material clearly, but still more to give time for the meaning to be grasped. They take up about 95% of the reader's time, the small remainder being all that the eye requires for its actual motion across the page, once the eye mechanics of reading are mastered in childhood. The eye as a machine is well able to operate faster than the mind can grasp the sense. Interest, by hastening the grasping process, increases the speed of the reading. The best time to form the habit of reading good books is between the ages of twelve and fifteen, because then the child is no longer interested in juvenile stories, and he will either begin to read sound literature or slip into the tabloid type.

FRENCH EXPEDITION TO TRAVERSE ASIA.

One of the most ambitious overland expeditions since the days of Marco Polo is planned for next spring. A group of eight caterpillar cars, each carrying a trailer, will traverse the whole length of the continent of Asia, starting from Syria and going to Indo-China by way of Iraq, Persia, Turkestan, Sinkiang and China.

The leader of the expedition is Georges-Marie Haardt, who achieved fame by being the first man to put a motor-car train across the Sahara desert. The personnel of the expedition is to be French, with the exception of representatives of the National Geographic Society, which will be the only foreign participant.

BACKGROUND AND FOREGROUND OF GENERAL SCIENCE.

No. XV. Sound and Hearing.

By Wm. T. Skilling,

State Teachers' College, San Diego, Calif.

General science text books and curricula are often criticized for emphasizing too strongly the physical phases of science as distinguished from the biological. In the above topic we have a combination of the two.

It reminds one of the threadbare questions as to whether a sound would be produced by a falling tree in a forest where there is no ear to hear it. Obviously the answer depends upon our definition of sound. If we say it is vibration of the atmosphere or some other substance at a rate somewhere between about 30 per second and 50,000 per second, the falling tree makes a sound. But if we define sound as an effect produced by the auditory apparatus whereby a nervous impulse reaches the brain, making us conscious of some of the things taking place about us, then without hearing there is no sound.

Both hearing in the physiological and psychological sense and sound in the physical sense are interesting science topics. Perhaps no general science unit of study lends itself so readily to simple and interesting demonstration and experiment work as does sound.

Then, too, it is a subject well adapted to the general science classroom because a considerable mass of information may be given which is not ordinarily obtainable in other ways by the pupils, and so will help to give them a respect for the course, a feeling that is sometimes lacking where inquisitive youngsters feel they are not "getting their money's worth."

Logically a good beginning in the subject of sound is to prove by demonstration that *vibration* of something is necessary to produce any kind of a sound. All kinds of stringed instruments including the piano are useful for this demonstration. The principle is as true for wind instruments but since the invisible air cannot be seen to vibrate they do not serve the purpose of a demonstration.

A yardstick held firmly down on a table or desk with one end projecting over the edge furnishes occular proof of the

vibration of a sounding body. Different lengths projecting will give different pitches.

A bell struck sharply can be felt vibrating. Or if a pencil be held lightly against its edge the vibrations become very evident.

The old fashioned tuning fork, though replaced by the pitch pipe for practical uses of the musician, is a good piece of sound apparatus for any school room. Its vibrations can be felt by the finger tips, or they may be shown by putting the vibrating part into a glass of water. It causes splashing and waves.

More beautifully and spectacularly, the vibrations may be recorded upon a piece of smoked glass. The wire for a marker should be wrapped firmly around the end of one prong, and made secure by sealing wax. A loose wire prevents continued vibration. Half an inch of the wire (the size of a broom straw) should project, and be drawn quickly across the smoked glass while sounding.

By a modification of the above demonstration one of the best lessons in the whole course from a scientific point of view can be given to the class. The seemingly impossible feat can be accomplished of counting the number of vibrations per second made by a sounding body though the number may run up into the hundreds. Such a demonstration will have a tendency to give them confidence in the findings of science about matters which seem to the uninitiated beyond human possibility of achievement.

The experiment mentioned consists in allowing a vibrating tuning fork to make its mark on a piece of smoked glass being turned like a phonograph record. Fasten the smoked glass to a piece of board some eight or ten inches square through the center of which a hole has been bored. Lay the board on the phonograph in place of a record, and regulate the instrument so that it will turn once a second. Then hold the sounding fork against the glass for a moment.

It is evident that counting the vibrations in one complete circle will give the rate of the fork.

Musical sounds, as distinguished from noises with no definite pitch, deserve a place in the general science class. The laws of musical sounds are found in any text book on physics, but the general science teacher's chief duty is to

search for demonstrations that will make it impossible for the normal child to fail to understand what various conditions determine pitch and loudness.

Of course the different kinds of musical instruments themselves are the natural source of demonstration material here. These can often be brought in, and perhaps demonstrated, by the pupils.

A simple and useful piece of improvised apparatus can be made by stretching a wire diagonally across a door. One end of the wire is attached to one of the hinges; the other end is passed under the knob and held in the hand. For convenience wrap the loose end around an eraser to serve as a handle.

By pulling with changeable force upon the wire different degrees of tension are observed to give higher or lower pitches when the wire is plucked. Quantitative results here are neither convenient or desirable.

A "bridge" slipped along under the wire serves to change the effective length of the vibrating part, thus making another law obvious.

A third law is easily demonstrated by using two wires of different size.

The effect of a sounding board in musical instruments is illustrated by the door. If two students stretch the wire from one to another each one pulling on one end, the sound will be scarcely audible. The wire will cut through the air without imparting to it much energy. The door with its more extensive contact with the air sets it in more violent vibration.

A more elaborate undertaking is the making of a marimba. Eight or more pieces are sawed from a strip of wood some ten feet long, an inch and a half wide and half an inch thick. Let the longest of these pieces be about eleven inches and each successive piece about half an inch shorter than the last.

Laid on two strips of thick felt and struck with a wooden hammer various pitches result. Tuning is done by sawing off a little from one end to *raise* the pitch and shaving off a little from the back with a plane to *lower* it. The "keys" may be tuned to each other or each tuned to a key of the piano.

Turning from musical sounds we find many phases of our topic susceptible of demonstration. Transmission of sound offers opportunities. Let each pupil press one ear against the desk and with the finger nails gently scratch the other end.

A wooden rod or strip some ten or fifteen feet long can also be used in a similar way to show the force with which sounds are carried in solids. As many as can find room along the strip can hear gentle rubbing at the end.

A "string telephone" made by connecting two tin cans with a strong, heavy string from ten to fifty feet long is another illustration of transmission through a solid. Attachment is made to each can by running the cord through a small hole in the center of the bottom of the can, and securing it by a knot inside. The string must be kept stretched very tight while it is being used. Better effects are had if the string passes through a door nearly closed, but it must not touch the door.

The use of a speaking tube is beautifully illustrated by a long garden hose. It should pass through a door or window so that only the sound that has come through the tube will be heard.

The behavior of echo from the side of a house or from a backstop on the base ball field may be studied for both time and direction of sound. The method of taking soundings at sea by use of echo from the bottom becomes clear after the above experiments.

The telephone and the radio are perhaps more suitably dealt with under the topic of electricity, but the phonograph is purely an application of the principles of sound. Information in regard to the making of phonograph records is interesting, but the principles underlying the whole subject are the important matters to clear up.

To show that the *record* rather than the phonograph is the essential part of reproduction turn the record without allowing the needle to touch it, but instead hold the corner of a visiting card or even the end of one's fingernail on the record, and music or words will be heard. A pin may be attached to the card for a little better reproduction.

To still further eliminate non essentials whirl the record in the hands on a lead pencil as an axis, holding the card

against it. Sound is heard though reproduction is poor because of irregular speed.

Look at the record with a magnifying glass and notice that the creases are wavy. As the phonograph needle or card runs through them it has to vibrate from side to side and it is of course these vibrations that produce the sound. The best places to observe the record with a glass is where long sustained and powerful tones are recorded. There the wavy appearance is most marked. Notice that the lines are smooth at the beginning and end of the record where no sound is recorded. (What made the creases wavy?)

A study of the phonograph is a good introduction to that of the telephone and radio for the latter rest upon the same principles as the phonograph, but with the added detail that electricity instead of a "record" is the connecting link between the original voice and the sound as finally heard.

MAUNA KEA.

There is a part of the United States that lies in the tropics, says the Geological Survey, but despite that fact snow falls there even in the summer time. Although the little group of islands in the middle Pacific that make up the Territory of Hawaii and which are just as much a part of the United States as is Pennsylvania, appear as hardly more than a dot on most maps of the world, they contain a mountain whose summit altitude is exceeded in only four of continental United States—California, Colorado, Washington, and Wyoming.

Mauna Kea, on the island of Hawaii, only 20 degrees from the equator, rises 13,784 feet above sea level, and although the island lies within the Torrid Zone the mountain summit is frequently white with fallen snow, and in winter it is deeply covered. This mountain is a volcano, but it is much older than Mauna Loa, at the other end of the island, and no eruptions from it have occurred during historic time. The climate was formerly so much colder than now that glaciers spread several miles from the summit, but they have all disappeared. The gentle and regular slope of the mountainside is supposed to be the result of the pouring out in former times of sheet after sheet of lava, which built up the great dome very gradually. The lava is in general so porous that most of the rain sinks into it without forming streams strong enough to cut deep channels in the smooth slopes.

The surface features of the mountain are clearly shown on the Mauna Kea topographic map, recently issued by the Geological Survey, Department of the Interior. This map represents an area of 280 square miles on a scale of about 1 inch to the mile, with a contour interval of 50 feet. A copy may be obtained from the Geological Survey, Washington, for 10 cents. An edition with green overprint showing woodland indicates that the forest cover is found over most of the northeast slope. This is a result of the direction of the prevailing trade winds that bring the moisture. The forest is irregular, however, varying with the porosity of the lava.—Department of the Interior.

PERMANENT EQUIPMENT FOR HIGH SCHOOL SCIENCES.

By A. C. MONAHAN,

Formerly U. S. Bureau of Education.

Before proceeding with the discussion of the cost of the permanent equipment for teaching the four ordinary high school sciences, and a comparison of these costs with those of other departments, it may be well to remind the science teachers who read this article just what is the problem before all high school science instructors and what they must do to meet it. Their problem is to create in the student body in their schools an interest in science somewhat proportional to the great popular interest in this subject on the part of the reading public. The public is "science-minded." It is using in every day life and work a large number of scientific instruments and pieces of apparatus that excites the curiosity to know about them and how they work and the science behind them. It is reading and studying in a serious way the several hundred science journals and the thousands of newspaper science items. High school pupils in their homes are in contact with these same influences and many of them are reading the same science journals. In spite of this, interest in science in the schools is constantly decreasing as evidenced by the decreasing enrollment, while interest in science outside the school is increasing at an almost unbelieveable rate.

To interest students, the school must have well equipped laboratories in which they work and see the results of their own work, and in which they can learn how to handle scientific instruments and set up apparatus for various experiments. They must feel that they are learning to use the kinds of instruments and do the kinds of things that they will have to do in their work after completing their school courses. The science instructor will not be provided with well equipped laboratories unless he shows his school officials that they are necessary, and that the cost is not prohibitive. The need will be determined by the number of pupils electing the science courses and the interest that they manifest in the courses when they have enrolled. Enthusiastic pupils, so interested that they talk about what they are doing in their laboratories to other students, is the best advertising the science department can have.

Well equipped laboratories and advertising will not in themselves make a successful science department. The teaching must be well done. It must concern itself with the subjects in science that have application in the outside world with which the ordinary boy and girl comes into contact. It must be a strong course, not too mathematical and theoretical, but practical and related to every day things. However, until the school has an enrollment in the science classes proportional to the outside general interest in science, it must take steps to advertise the science work just as home economics, manual training and agriculture have been advertised, and it must have good laboratories. Popular demonstration-lectures by the instructor assisted by students, or by students assisted by the instructor, has proved very effective. The article in the November number of this journal by Carl F. Hanske entitled *A Science Auditorium Program,* gives an excellent suggestion. The one by M. N. States in the December number is suggestive also. There are several in this number that will let the science teacher know what others are doing to promote their work.

Contact with a large number of high schools throughout the United States and with various school surveys has convinced the writer that outside of the larger city high schools, the great majority of them are inadequately equipped for efficient science teaching, with space, suitable furniture and apparatus. He feels that the Scientific Supply houses are in part to blame. Several of them distribute to school superintendents priced lists of apparatus and science supplies for high school classes. Practically all such lists are far too limited, superintendents and principals have assumed that they were adequate and have made their allotments to the science departments on the prices included. State Departments of Education have been influenced also by these lists in the preparation of the so-called State Lists of Science Equipment, with the result that many of them do not include enough equipment to make the giving of a satisfactory course probable.

Jensen's study of the science departments in the 469 public high schools of So. Dakota, made two years ago, may be cited as an evidence of the truth of the statement rela-

tive to the inadequacy of the equipment in the smaller schools. The results of the study are published in the *Journal of Chemical Education* for April, 1929.[1] The figures below summarize the data for the 278 schools on the State accredited list.

General Science	No. of Schools,	110;	Average value equipment,	$122;	Range	$10	to	$ 400
Biology	"	"	72;	"	"	"	197;	"	16	to	200
Chemistry	"	"	63;	"	"	"	332;	"	10	to	1,800
Physics	"	"	151;	"	"	"	420;	"	10	to	1,850

The State Department of Education of Oklahoma publishes a list of apparatus and supplies for its accredited schools. At current prices the materials included would cost the amounts given below. The writer is of the opinion that an amount at least 50% greater is needed for satisfactory work. The larger city schools usually have twice as much per student as this.

Class of	8 pupils	16 pupils	24 pupils
General Science	$122	$187	$244
Biology	217	400	583
Chemistry	233	395	591
Physics	389	587	766

A more nearly adequate allotment is given in a recent bulletin of the U. S. Bureau of Education entitled *Laboratory Layouts for the High School Sciences.*[2] The lists were made in collaboration with a number of science teachers and may be regarded as satisfactory for average sized schools but not for the large city school.

			Annual replacements
Class of	8 pupils	24 pupils	24 pupils
General Science	$190—$ 250	$ 300—$ 350	$ 50—$100
Biology	350— 700	600— 910	60— 200
Chemistry	450— 800	700— 1,000	240— 360
Physics	700— 1,400	1,590— 2,240	200— 360

Laboratory rooms and laboratory furniture is the next consideration. How many and what rooms are needed and what types of furniture are the most satisfactory. First it may be said that it is no longer thought necessary to have separate "lecture rooms" for high school science classes, except perhaps in the very large schools where laboratories and lecture rooms are both in almost constant use. They are being discarded because it is found, in the

[1] *An Investigation of Types of Classrooms for Chemistry and Other Sciences in Small High Schools*, by J. H. Jensen and Earl R. Glenn, of the State Teachers Colleges at Aberdeen, So. Dakota and Montclair, N. J., respectively.

[2] U. S. Bureau of Education Bulletin 1927, No. 22. A limited number of both of these publications may be had without cost by subscribers of SCHOOL SCIENCE AND MATHEMATICS on application to the Editor.

great majority of schools, that they are not used constantly enough to warrant the cost, and particularly because space in the laboratory itself for demonstration-lectures on the part of the instructor and for recitations is a decided educational advantage. The instructor may stop individual laboratory work at any time that he finds that the students need instructions, he can assemble them quickly in the space provided in the laboratory. He has a space available also for the more rapid students when they have completed their experiments, where they may sit and write up their notes or study. He can split periods between recitations and laboratory work. He has his apparatus and supplies all in one room handy to get at for either types of work.

The plan now generally recommended is either (1) to provide space at one end of the laboratory large enough for 24 student tablet armchairs and an instructors demonstration-lecture table, or (2) to use special furniture which permits students to sit at their work tables during demonstrations and recitations, the instructor being supplied with a lecture table. In General Science and Biology there is no problem. The usual type work table provided the students permits them to stand or sit. With the better type the pupils work on one side of the table only, so all are facing the front of the room at all times. At the front is placed the instructor demonstration table. In Physics a similar table can be used, but most instructors prefer a four-student table because so often in Physics four students work together on one experiment. With the old type of furniture in Physics and in Chemistry it is almost necessary to provide the space for seating at one end of the room. If however the Lincoln type table is used students sit in their working spaces and only space at the end of the room for the instructor need be provided. The Lincoln table was developed at the Lincoln School, Teachers College, Columbia University, to meet this particular problem. It is now in use in many hundreds of high schools throughout the country so may no longer be regarded as an experimental piece of furniture. It is made up of a continuous table the length of the room composed of T shaped units, each unit for two pupils. In the leg of each

T between the two pupils is a common sink. The pupils all face in one direction at their work whether standing or sitting. When seated at demonstrations or during recitations or when writing up their notes, they are facing the front of the room. They use chairs which fit in under the ends of the cross sections of the tables when not in use. There the chairs are handy but are out of the way when pupils are standing engaged in their experiments.

The arrangements for this table and for other forms of dual purpose tables, also for space in the laboratories for recitations and instructor-demonstrations, are thoroughly described in the two publications mentioned in this article, Mr. Jensen's report on his investigations in So. Dakota, and the U. S. Bureau of Education bulletin. They are described also in a valuable recent report of the *National Research Council* affiliated with the National Academy of Science at Washington, D. C. It is a report by a committee on Chemistry Laboratories, entitled *Laboratory Construction and Equipment.*[3] These reports make it unnecessary to go further into a description of the matter here.

The number of Laboratory-Lecture combination rooms depends upon the size of the school, of course, and the number of pupils in science classes. The class which can be handled by one instructor to the best advantage is approximately 24 pupils. A joint laboratory-lecture room for 24 students requires a floor space 22 or 24 feet in width and 42 or 44 feet in length. This is sufficient length so that six to eight feet at the front end can be cut off to form one or two supply rooms. Either arrangement suggested above can be put in this space, although the Lincoln table gives more open space.

In a school of 1,000 pupils, if the percentages of enrollment in the various subjects holds, as they will in the majority of schools, there will be approximately 200 pupils in General Science, 160 in Biology, 72 in Chemistry and 70 in Physics. In sections of approximately 24 pupils, the school will need two laboratories for General Science, two for Biology, and one each for Chemistry and Physics. The rooms would be in use either for laboratory work or for recitations, from two-thirds to five-sixths of the school day.

[3]Copies are obtained from the Chemical Foundation, New York, which published the report. Price one dollar.

In a school of 500 pupils in four year high school work, one laboratory for each of the four science subjects would be required ordinarily. The Chemistry and the Physics classes may use the same room if it is equipped with the proper furniture. This would be the Lincoln type table or some other special design for use in both subjects, such as the four-student center-sink type. In a school of 250 pupils, two laboratories are needed. One would ordinarily be used for General Science and Biology, the other for Chemistry and Physics. In some schools General Science and Physics are given the same room, Biology and Chemistry the other. This is because science men often fear that the chemical fumes in the laboratory used for this subject will injure the instruments and apparatus used especially in Physics. There is a danger. Any metal in a chemical laboratory is in danger of attack by the chemical fumes. If the same laboratory is to be used for Chemistry and Physics, it must be provided with mechanical ventilation; two separate supply rooms must be provided, one for chemicals, the other for apparatus, and both must be ventilated.

Laboratory furniture built by any of the companies specializing in this type of equipment will cost for the four laboratory-demonstration rooms somewhere from $3,500 to $6,800. This allows for working space for 24 individual students in each of the four laboratories, an instructor demonstration-lecture table in each, a six foot chemical fume hood in the chemical laboratory, and chairs for the pupils in all. Separated by rooms, the cost for furniture is about $780 to $1,500 for the General Science laboratory, about the same for the Biology, $680 to $1,350 for the Physics, and $1,500 to $2,500, for Chemistry.

Of course, much cheaper furniture can be used such as might be built on the job by a local carpenter, but it is never satisfactory. The tops warp and crack and are not usable for scientific instruments if accurate results are to be obtained. They have passed out of use, as homemade seats for pupils and homemade desks for teachers have passed. Well made factory-built furniture will last in good condition as long as the building lasts if given proper care. The type of furniture influences the students in their work. Rough carpenter-built science tables promote indifference

on the part of pupils and slovenly work; good furniture encourages neatness and with it accuracy which is an essential of a good science course. The live science instructor will insist on proper furniture for his laboratories.

PERMANENT EQUIPMENT FOR OTHER DEPARTMENTS.

Laboratories for Home Economics, Art and Drawing, Drafting, and Agriculture require about the same floor space in each as the science subjects. Woodworking and other high school shop subjects require 20 to 50 percent greater floor space. Typing and Bookkeeping rooms require less. The medium sized schools doing satisfactory work in these subjects have usually a Foods Laboratory, a Clothing-Textile Laboratory, and one room in each of the other subjects mentioned. In some schools a "general shop" is provided, equipped for woodwork and metal work, and sometimes for electrical wiring, printing and other trades. Larger schools making a special feature of their Home Economics work usually have a small model dining room, a laundry, a bed room, and often an art room for clothing design and interior decorating classes.

Below is a table of approximate costs of these various departments. Such costs may vary greatly from those given here. These are not mere guesses; they are from reliable sources, including a bulletin of the Federal Board for Vocational Education entitled, *"Plant and Equipment for Vocational Classes in Home Economics"*; a mimeographed circular of the U. S. Bureau of Education; *The General Shop*, a bulletin of the Bureau; and printed circulars of State and City Departments of Education. Furniture costs were obtained for layouts recommended by these various authorities direct from one of the best known manufacturers of laboratory and vocational furniture. Those given are for standard factory-built tables, benches, desks, cabinets, etc.

The costs in the table are all for classes of 24. In the four sciences working space for each of 24 pupils is provided, an instructor's demonstration table, 24 tablet arm chairs for recitations, and such other necessary articles as aquaria for General Science and Biology, chemical fume hood for the Chemistry laboratory, etc. The Foods Labora-

TABLE OF COSTS OF HIGH SCHOOL DEPARTMENTS, LABORATORY AND SHOP SUBJECTS.

(*Each for 24 students in a section*)

Subject	Furniture Laboratory tables, benches, chairs, etc.	Machinery, Apparatus, Utensils, Tools.	Usable supplies, chemicals, groceries, lumber, etc.
General Science	$ 780—$1,500	$ 250—$ 350	$ 50—$100
Biology	780— 1,500	560— 810	50— 100
Chemistry	1,500— 2,500	800— 900	200— 300
Physics	680— 1,350	1,490— 2,040	100— 200
Foods	950— 1,550	300— 600	100— 240
Clothing	950— 1,900	320— 550	50— 200
Drafting	900— 1,350	150— 300	.....
Art, Drawing	730— 1,100	150— 300	.....
Woodworking	700— 1,500	2,100— 5,000	200— 500
Typing	300— 900	600— 1,440	.....
Bookkeeping	600— 1,200	200— 600	.....
General Shop	400— 1,000	2,000— 3,000	300— 600

tory includes three parallel rows each for eight pupils composed of the following in this order: kitchen gas range, table for four girls, double sink, table for four girls, and another range. A supply table is included, also an instructor's desk, 24 stools for the work tables and 24 chairs for recitation.

In Clothing there are 12 double student tables, an instructor's table, a cutting table, a storage cabinet for individual pupil materials, a wardrobe, a mirror, a fitting stand, and 24 student chairs and one for the instructor. Sewing machines are under the second heading. Under Woodworking are included 24 benches, a glue table and storage cabinets. A Universal saw table, a joiner, and other necessary machines are in the machinery column.

WHAT DO YOU KNOW ABOUT THE AMERICAN EAGLE?

Mr. Charles M. Shipman, President of the Burroughs Nature Study Club of Cleveland, presented three reels of film and some colored slides at the thirtieth annual meeting of the Central Association in Milwaukee on the nest life of the Eagle.

Working with Dr. Herrick of Western Reserve University, Mr. Shipman has made several thousand feet of film taken from a blind on an eighty foot tower where he could look down into a nest seven feet in diameter. At this vantage point, he spent six to twelve hours a day for some six months. These pictures were made at great cost of time, patience, and inconvenience.

Mr. Shipman has a message that many of our high school pupils should hear, and he presents it in a fascinating way.

THE LEARNING PRODUCTS OF A UNIT OF INSTRUCTION IN MATHEMATICS.

By C. A. STONE and J. S. GEORGES,
The Laboratory Schools, University of Chicago.

PART I.

As stated in the preceding article,[1] instructional materials are organized into convenient units of instruction for two definite purposes: First, a division of the related parts of a course into units permits a gradual development of the concepts, principles and processes of the course and provides steps into learning process; second, the essential concepts, principles and processes of each unit provide means of measuring the learning products of each course. Further, it was pointed out that though the purposes of organization of the subject matter into units of instruction may be fundamentally the same, yet the actual formulation of the units will be to a large extent arbitrary, and will depend upon the principles used as criteria in terms of which such units are evaluated, whether these criteria are explicitly stated, or implicitly assumed by the organizer. The first of the seven criteria for the organization of subject matter into units of instruction, enumerated in the preceding article, namely, *each unit of instruction must furnish definite learning products* which automatically become the aims to be attained, will be considered in this discussion.

Definition of Aims: The determination of aims of instruction has been a vital problem in curriculum making, for which no definite solution can be said to have been found, nor that a satisfactory solution may be found. Attempts have been made to evaluate the aims of mathematical instruction in the secondary school but one fails to find in the vast literature dealing with the subject the clarity of meaning and preciseness of terminology that is usually attributed to mathematics, hence reasonably expected of writers on mathematical subjects. One often finds such terms as "objectives," "aims," "purposes," "values," "uses," "reasons," and "advantages" used to connote learning products in mathematics.

No matter how the process of education itself may be

[1] Stone, C. A., and Georges, J. S. *The General Principles of Unitary Organization.* SCHOOL SCIENCE AND MATHEMATICS, November, 1930.

defined and interpreted, whether as an adjustment of the individual to the world, or as a preparation for right living, or as a development of certain desirable attributes, it is reasonable to *define the aims of instruction* as the *learning products which are actually acquired through assimilation* of the *instructional materials*. The understanding of concepts and principles, the mastery of processes, the attainment of skills and abilities, the development of abilities to use processes and principles are the real aims of instruction. Accordingly many of the "reasons" advanced for the teaching of certain facts, concepts, principles and processes of mathematics cannot be called aims of instruction since they are only arguments advanced in the defense of such elements of mathematics which are proposed to be taught. Similarly, the enumeration of "values," "uses," "applications," and "advantages" of the teaching of mathematics in terms of certain facts, concepts, principles, and processes should not be considered as a determination of the aims of mathematical instruction. Such an enumeration may be very helpful in deciding why certain items should or should not be selected and included in a course, but the aims themselves are to be interpreted in terms of the acquisitions of such items which are actually selected. The real issue is not always clearly stated in the literature dealing with the subject: i. e., are the facts, concepts, principles, and processes selected for the various courses the real aims, or are they used only as means of attaining certain other ends, which are the true aims of mathematical instruction.

Nature of Aims: The confusion regarding the meaning of aims in the teaching of mathematics manifests itself in the attempt to describe their nature. According to Schultze,[1] "Mathematics is primarily taught on account of the mental training it affords, and only secondary on account of the knowledge of facts it imparts." That the specific tasks, set up in the course, to be performed by the pupil, which are considered as the teaching objectives by many writers, are not the aims but means for the attainment of the ends is clearly stated by Young.[2] "Power to think and to do is the ultimate end," he says, "the acquisition of facts is rather one of the instrumentalities used in the attempt to develop

[1]Schultze, Arthur. *The Teaching of Mathematics in Secondary Schools*, p. 29.
[2]Young, J. W. A., *The Teaching of Mathematics*, p. 13.

this power than itself the end of education." It seems then that the nature of the aims in the teaching of mathematics is two-fold, first the primary or chief end, or ends, which constitute the real purposes of mathematics, and second, the acquisition of certain facts which in themselves are not to be considered as ultimate aims, but are helpful in attaining the chief aims. These chief or general aims are "to be sought in the nature of the subject, the role it plays in the practical, intellectual, and spiritual life of the world, and in the interests and capacities of the students," according to the National Committee on Mathematical Requirements.[4]

This two-fold nature of the aims of mathematical instruction is interpreted still in another light. Smith and Reeve[5] consider objectives as of two kinds, the *central objectives* which are not peculiar to mathematics but are the aims to be sought in all fields of knowledge, and the *general* and *specific mathematical objectives* which treat of the nature and uses of mathematics. For example, "to develop well-educated citizens" is considered by these authors the *central objective* in junior high school, and thus in the teaching of mathematics, as in all other subjects, this purpose is to be constantly kept in mind, while "a strictly mathematical objective is to give the pupils in the junior high school some idea of the general nature and uses of both business and social arithmetic—" if objectives are to be interpreted as specific purposes of mathematical education, it is evident that such broad aims of education—to develop well educated citizens—or general aim of mathematical instruction—to give some idea of the general nature and uses—have no definite and intrinsic effects upon the teaching procedure.

Morrison,[6] who defines aims of teaching as learning products, considers them as of three distinct types; first, attitudes of understanding; second, attitudes of appreciation; and third, special abilities or skills. These three types of learnings, which may be made the aims of teaching, are illustrated by the concept of function. The functional representation of dependence and variation may be made an aim in acquiring understanding; the manipulations of the algebraic function, such as evaluation or graphing, as aims

[4] *Reorganization of Mathematics in Secondary Education*, p. 2.
[5] Smith, D. E. and Reeve, W. D. *The Teaching of Junior High School Mathematics*, p. 1.
[6] Morrison, H. C. *The Practice of Teaching in the Secondary School*, p. 21.

in acquiring special abilities. These aims are learning products which can actually be acquired and if they be made the definite aims to be attempted in any unit of course then they become ipso facto the aims of instruction for that unit or course.

Classification of Aims: In order to arrive at definite aims for each unit of instruction in mathematics it is necessary to consider briefly a classification of mathematical aims, for thus we shall be led to an understanding of their nature and significance which is to determine an evaluation of a unit in terms of the learning products it presents.

The Traditional Classification: The traditional formulation of the aims of mathematical instruction in secondary schools distinguishes between three types or classes: (1) the practical or utilitarian aims; (2) the disciplinary aims; and (3) the cultural aims. These classes are not mutually exclusive, hence there is an overlapping in the listing of their elements, and various interpretations of their exact nature. The National Committee on Mathematical Requirements[7] gives a list of aims for each of the above classes which may be considered as representing the crystalized opinions of the teachers of mathematics.

The "Primary" and "Secondary" Aims: One or more of these aims often receive emphasis in the textbooks on the teaching of mathematics, or in articles discussing the genuine functions of mathematical instruction. Smith, for example, has emphasized the ethical value[8], that is, the value of the subject whose aim is the search for the truth; and even the values of mathematical concepts in religious doctrines.[9] The esthetic values, the pleasures of which are akin to those of painting, and music, are emphasized as real and genuine mathematical aims in Poincare's writings.[10] The ethical and esthetical values of mathematics, as indispensable factors of a general education in the understanding of the development of civilization and in the ability to participate in the further tasks of civilization, have been formu-

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[7]*The Reorganization of Mathematics in Secondary Schools*, pp. 6-10.

[8]Smith, D. E., ibid. p. 170.

[9]Smith, D. E. "Religio Mathematici." The American Mathematical Monthly, XXVIII, October, 1921, pp. 339-349.

[10]For example, Poincare, Henri, "Sur les rapports de l'analyze pur et de la physique Mathematique," Report of International Congress of Mathematicians at Zurich, 1897, p. 82.

lated by a large number of mathematicians and mathematical societies and associations.

The disciplinary values of mathematics have been considered by many writers as constituting the chief aim of mathematical instruction. "Mathematics is taught primarily on account of the mental training it affords," states Schultze,[11] "and only secondarily on account of the knowledge of facts it imparts;" and he formulates it in terms of developing reasoning power. Young also agrees that the chief value of the study of mathematics[12] is "the fact that it exemplifies most typically, clearly, and simply certain modes of thought which are of the utmost importance to everyone." Mathematics as a mode of thought, specifically functional thinking, has been made the primary aim of mathematical instruction by the National Committee.[13] Due to the influence of Klein in Germany, Borel in France, Perry in England, and Moore and others in America, the more recent viewpoint considers the basic concepts as the primary aims of mathematics in secondary school, such, for example, as the concept of function, in the dual role both as a central theme in coordinating mathematical instruction, and in utilizing mathematical training to develop a scientific attitude toward the life and the world.

Whenever it is advocated to place emphasis in teaching on any particular class of aims, or the elements of that class, an attempt is made to consider such aims which are to be emphasized as "primary aims," i. e., of primary importance, while other aims are considered as "secondary aims," or of secondary importance in the teaching of the subject. A list of aims considered as "primary aims" of mathematical instruction by one writer may thus include elements which are included in a list presented by another writer entitled "secondary aims" of mathematics.

A representative list of "primary aims" is given below:

1. Acquiring understanding and ability to use the fundamental operations.
2. Developing understanding of and ability to use algebraic representation.
3. Acquiring an understanding of quantitative concepts and abilities to use processes of measurement and representation.
4. Developing ability to recognize and understand quantitative relationships.

[11] Schultze, Arthur. ibid, p. 29.
[12] Young, J. W. A. ibid, p. 41.
[13] Reorganization of Mathematics in Secondary Education, p. 10.

5. Developing ability to determine and express quantitative relationships.
6. Developing logical reasoning, the ability to draw logical conclusions and inferences.
7. Developing ability to generalize relationships.
8. Developing ability to recognize special cases and to apply general laws.

While the following list is representative of "secondary aims":

1. Acquiring information of mathematical facts and results.
2. Acquiring appreciation of the power of mathematics.
3. Acquiring appreciation of the concepts of mathematics, such as beauty and symmetry.
4. Establishing certain desirable habits of study.
5. Developing cultural attributes.
6. Establishing correct habits of conduct.

"General" and "Special" aims: A second method of classifying the aims of mathematical instruction, and one which represents more closely the practice in classifying objectives is to distinguish between the so-called "general aims" and "specific" or "special aims." This method also may be approached from two different points of view.

The first would include under the "general aims" all aims of education which are sought not only in mathematical instruction but also in other subjects, while the "special aims" would necessarily include all such aims as are mathematical in nature and are peculiar to the study of mathematics. In essence this is the classification followed by Smith and Reeve.[14] Such aims as the establishing of the habits and methods, of neatness, of thinking, of moral conduct, of character, of simplicity of language, of accuracy of reasoning, and of originality of thought, whose attainment is claimed to be facilitated by the study of mathematics are listed under the "general" or "central objectives," while the list of special objectives includes such items as the applications of mathematics, appreciations of its powers, the increase of certain powers as of construction and interpretation of graphs, and fostering the study of mathematics, which are strictly mathematical.

The other point of view of classifying aims as "general" and "special" is more definitely mathematical in its scope. Here the "general aims" are those facts, concepts, processes, and principles which are of fundamental significance in mathematics as a whole, and though they may be treated

[14]Smith, D. E., and Reeve, W. D. ibid, pp. 23-27.

in a particular unit or course, their attainment is not accomplished there. Function concept, or rather, functional thinking is considered by many writers as the most fundamental aim in the teaching of mathematics.[15] The "special aims," on the other hand, are specific concepts, principles, or processes, which are the ends to be attained in a particular unit or course. They may be in terms of skills, abilities, or understandings which are in themselves the ends to be attained, or they may serve as a means toward the attainment of the more "general aims." The "immediate objectives" listed in the various courses of study are of this type.[16]

The Primary and Secondary Aims of a Unit: The primary aims of a unit of instruction are *defined to be such mathematical learnings which are to be completed in the unit,* such *adaptations which are actually set up because* of the *instructional materials* of the *unit,* and such *definite tasks which* at the end of the *unit* are *said to have been completed* and *mastered.* The *secondary aims* of the *unit* are *such habits, adaptations, understanding* and *skills toward* the *realization* of which the *unit makes* definite *contributions* but *may not* be *completely attained* in any one particular *unit.*

A distinction between aims which are mathematical in nature and other general aims in the attainment of which mathematical instruction aids is of utmost importance to the teacher of mathematics for effective and purposeful teaching. Concentrated effort must be directed on definite tasks, whose complete mastery must be strived after. To that extent each unit of instruction must have definite primary aims, whose attainment in that unit must be aimed at. It will further have definite secondary aims. In importance to contingent values these secondary aims may outweigh the primary ends of the unit. But as far as their attainment is concerned they are secondary in the sense that they are not attained in any particular unit, or any particular course, but are the general aims of the educa-

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[15]The reader is referred to the following articles:
a. Hedrick, E. R. Mathematics Teacher, April, 1922.
b. The Organization of Mathematics in Secondary Education, p. 9.
c. Dresden, A. School and Society, XII, October, 1920.
d. Breslich, E. R. Third Yearbook, The National Council of Teachers of Mathematics, p. 42.
e. Georges, J. S. SCHOOL SCIENCE AND MATHEMATICS, XXVI, October, 1929.
[16]For example, the Course of Study of Denver, Colorado.

tional system. The instruction in a given unit contributes something definite toward their realization. Hence they are definite.

For purpose of illustration we may take a unit of instruction in junior high school mathematics which is based on the graphic representation of quantitative data. The primary purpose of the unit here is the understanding of the graphic method, and the formation of the special skills and abilities in the making as well as interpreting graphs. This is a unique mathematical process and hence a definite mathematical learning to be aimed at. In the presentation, the development, and the assimilation of the unit, there are certain closely associated learnings that must be taken into consideration. These are the secondary aims of the unit on graphs. Some of them, such as approximations, that is, the rounding off of numbers, and selection of units, are mathematical learnings which are also considered in other units, say, in a unit on direct measurement, or on indirect measurement; while other learnings, such as intensive reading, neatness and accuracy of thought and expression are aims that are sought after in all subjects and cannot be called unique functions of mathematical instruction. Yet they are real, and of utmost significance.

Secondary Aims of Two types: The aims toward the attainment of which the instruction in a unit makes definite contributions but which are not completely attained in any one particular unit are of two general types: First, the *general function* of *mathematics*, and second, the *aims* of *education*. Significant mathematical concepts, processes and principles which are carried over from unit to unit and from course to course are of the first type; while, the general and specific aims of education toward the realization of which each course makes definite contributions are of the second type. These latter aims are not unique functions of mathematics, but are common to most, if not all, the subjects of secondary schools.

The statements below are items of lists that have been compiled from various sources[17] and represent the types of

[17]First Yearbook of The National Council of Teachers of Mathematics, pp. 76-80; Second Yearbook, pp. 125-142; Third Yearbook, pp. 11-23, 24-34, 35-41, 42-56, 149-194.
Also: Smith, D. E., and Reeve, W. D., ibid.
Young, J. W. A., ibid.
Koch, E. H. "Training For Efficiency in Elementary Mathematics," Mathematics Teacher, III, pp. 170-184.

learnings which may be made the definite aims of a unit of instruction in mathematics. Here the lists of abilities, understandings, and appreciations represent the secondary aims which are mathematical in nature, and the lists of developments of habits and powers represent the aims of education not necessarily mathematical. The various items of the first list may be selected for complete mastery in a unit, and when so selected, taught and learned, they then become primary aims, otherwise they must be grouped with the secondary aims of the unit. Most of the items of appreciation are secondary aims, as they are developed and strengthened by all the units of the various courses in mathematics.

The lists of typical mathematical aims follow:

Abilities:

To compare data; the difference method, the ratio method.
To represent quantities symbolically (algebraic representation).
To compute rapidly and accurately.
To evaluate expressions for specific values (arithmetical values, algebraic values).
To transform formulas representing relationships into simpler ones.
To solve equations (linear, quadratic).
To compute by means of logerithms.
To find areas of geometric figures.
To express relationships between variables and constants.
To discriminate between hypothesis and conclusion.

Understandings:

The "ratio" method of comparison of data.
The evaluation as going from the general to the specific.
The transformation of relationships (formulas) into simpler ones (form, or number of variables).
The solution of equations, (linear, quadratic, linear system, linear-quadratic system).
The exponential representation (large and small numbers).
The trigonometric functions.
Variation (direct, inverse, joint).
The notion of number.
The logical proof.
The mathematical theory of limits.

Appreciations:

The exponential representation.
The ideal accuracy.
The succinctness of mathematical statement of laws as functions.
The universality of function concept.
The significance of the number system.
Mathematics as a mode of thought.
The notions of symmetry, as interpreted in mathematics.
The economical aspect of mathematical processes, both as to time and effort.
The invariants of life, and the world.
The reign of law, the absoluteness of law.

The list of typical non-mathematical aims presents:

Developing the habits of:

Accuracy of thought and expression.
Simplicity of statements.
Seeking certainty of results.
Systematic procedure.
Intensive reading.
Economy of time and effort.
Clearness in presentation, oral and written.
Checking one's conclusions.
Subordinating the dependent elements.
Organization of materials.

Developing powers in:

Simplicity of language.
Accuracy in reasoning.
Observations.
Analysis.
Generalization of results.
Symbolic representation.
Exercising common sense.
Interpreting the economic environment.
Applying information to useful purposes.
Individuality.

A CHEMICAL EXHIBIT USED TO INCREASE INTEREST IN HIGH SCHOOL CHEMISTRY.

By MARY I. WOOLLEY,

Murphy High School, Mobile, Ala.

The Mobile student faces the following situation in his science program: a choice of either biology in the sophomore year or physics or chemistry in the junior or senior year. It would appear that chemistry was not appealing to the students of Murphy High judging from the small number who elected it. In the spring of 1928 only 2.72 per cent of its pupils were taking chemistry, even though it was found from the replies received from fifty-two leading high schools of Alabama that the state of Alabama as a whole had 9.2 per cent of its high school students electing chemistry, which was greater than the per cent given for the nation as a whole[1]. Immediately materials and methods were sought by which this condition in Murphy High could be corrected. Just at this time the Journal of Chemical Education published the article, "A Chemical Exhibit," which, as worked out by Bell[2], seemed to offer a solution to the problem.

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[1]United States Bureau of Education, 1928. Bulletin 35671.
[2]Fannie Bell, "A Chemical Exhibit," in the Journal of Chemical Education, (1928), 5, 280-6.

The first step in carrying out the program was the preparation of a list of industrial topics suggestive of various possibilities. Each student was asked to select from the list a commodity in which he was interested or for which he thought he might be able to get an exhibit. He was to show the source, the steps in the manufacture, and the uses of his particular commodity. A list of addresses of concerns where the materials could be obtained was secured from Bell, "Chemical Exhibit," and placed on the chemical bulletin board.

The individual pupil, after selecting his topic, went to the library as his first source of information. When the pupil had read sufficiently to get an idea of the scope of his subject, he selected a particular phase of it and presented it to the instructor for approval. As soon as the teacher passed upon his selection, the student began to gather his material. He wrote to the companies on the list which has already been mentioned, to friends who were in positions to aid him, and to companies who had advertised materials to be given away. All of these concerns were prompt and courteous and generous in dispensing materials. Each one sent enough literature for every member of the class. The next step was the arrangement according to a definite plan of all the material collected and the approval of this plan by the teacher. The students came to the work room or to the manual training department during study periods or after school to prepare their projects. The actual preparation of the project was done by means of charts and samples. All materials sent out by each industrial company was accompanied by a chart or a pamphlet which explained the use and the preparation of the material. For example, the Bell Telephone company sent a pamphlet naming all the chemicals used in the structures of the telephone and where, in the instrument, each is employed. This was one of the best exhibits in the class. A detailed explanation would no doubt be interesting and helpful. A Chart was placed on the wall which contained actual samples and illustrations of these samples of all chemicals used in making a telephone. Under the chart, against the wall was placed a table on which were all the parts of the telephone itself. Standing on the table

near the wall were three miniature telephone poles connected by wires, of the kind used for actual telephone wiring, also strings were used to show the relation between each chemical on the chart and the particular part of the telephone in which it was used. This was made clear by fastening one end of a string to the element on the chart and the other end to a part of the instrument lying on the table.

The exhibits as prepared fell into three different classes: one type was the combination of explanatory chart and samples of material, both sent by a company to whom the student wrote for it; a second type was made by using the material sent by the company in combination with a chart made by the student; the third type was the one for which the company sent a chart and the student had to gather the material with which to explain it.

Each day the first part of the class period was given to the student who had completed an exhibit. He arranged it on the demonstration desk and explained it thoroughly. Literature was distributed to the other members of the class so that they did not need to take notes. They asked questions and had discussions but they were not responsible for any of this on examination, because the instructor wished the work to be spontaneous, with no feeling of obligation or compulsion whatever. As each student finished his project, he placed it on exhibit in a hall used for that purpose. For three weeks before time for selecting the courses of study for the following year, at least one new exhibit a day was placed on display. In this way, interest in chemistry as a subject for study was built up. During the three weeks' exhibition, two chemistry students were in the exhibit hall before and after school and at lunch periods to explain the charts.

The ultimate aim was fulfilled and the goal reached, when the enrollment for the year 1928-1929 in the chemistry department was double that of 1927-1928. Enrollment is still on the increase.

Statistics show that one-half of all the mining done in the United States is for fuels, one-fifth for construction materials, and one-fifth for base metals. These percentages are based not on actual mining operations but on millions of dollars output.

A UNIT IN NINTH GRADE BIOLOGY.

By LOUISE HERRICK,

General Science, Roosevelt Junior High School, Rockford, Ill.

ASSISTED BY PAUL A. JOHNSON AND VERONA M. PRIEN,

Lincoln Junior High School, Rockford, Ill.

Rockford has recently inaugurated a six-year program of science education throughout the secondary schools. The science teachers of the two junior high schools have cooperated in experimenting with units and methods of procedure for pupils of this grade level. The senior high school requires one year of laboratory science for graduation, but allows free elective choice, from among Botany, Zoology, Chemistry, Physics, and Psychology. The required work of the junior high school covers the following topics:

7B	Health—Auditorium	1 period per wk.
7A	Our Immediate Environment	2 and 3 periods per wk.
8B	Earth Science	2 and 3 periods per wk.
8A	Physical Science	2 and 3 periods per wk.
9B	General Biology	4 and 5 periods per wk.
9A	Human Biology	4 and 5 periods per wk.

The method in the ninth grade originally attempted was the Morrison Plan. The number of pupils per teacher and the type of pupil in the slow groups made repeated reteachings impossible. However the Units are prepared with guide sheets which are preceded by a pretest, presentation and presentation test before the work is handed to the class. In fast and high average groups, these sheets serve as a guide for one or two weeks, according to the length of the unit. The teacher performs all necessary demonstrations, but for the most part the teacher merely supervises during this period. At the end of the unit, Morrison's Plan for organization and recitation is followed. The first two or three units do not offer inspiration to an ambitious teacher but, by the end of two semesters, a high percentage of pupils have mastered the technique.

The third unit of the ninth grade course is selected as an example of organization. This is preceded by the units "How Living Things Differ from Non-Living Things" and

"How Living Things Depend Upon Their Physical Surroundings." . . .

DIRECTIONS FOR USING THE GUIDE SHEETS.

These sheets are merely a guide for the study of the subject. When you first receive a new unit, you should:

A. Read the Unit heading thoughtfully and keep it in mind as you proceed in your work.

B. Read carefully, the statements "After finishing this unit you should know"—and see if you can understand them. Keep them in mind as you work out the exercises in the unit.

C. Look over the definitions given for the new words you will use in the unit. Memorize these terms so that you will understand your reference reading.

D. References to the books which you will find in each classroom are given at the beginning of each unit. Remember that no *one* reference will answer all of the questions.

E. You will find the following set of reference books in each classroom:

"General Science," Bowden
"Everyday Problems in Science," Pieper & Beauchamp
"New Biology," Smallwood, Reveley & Bailey
"Biology for Beginners," Moon
"Living Things," Clement
"Our Environment" Book III, Wood & Carpenter
"Physiology and Sanitation," Ritchie

F. By use of the reference books, look up the answers to the questions under the exercise. You should find the answer to each question in at least three reference books before attempting to write it in your note-books. This answer should not be statements copied word for word from the reference book, but your own conclusion and opinion after reading different books.

UNIT III. HOW LIVING THINGS OBTAIN AND STORE FOOD.

PRETEST

1. What raw material does a plant use to manufacture food?
2. By what process do plants take food from the soil?
3. Why is green coloring matter necessary to a plant?
4. How does the food of a horse differ from that of a dog?
5. Name some plants that cannot manufacture their own food.
6. How can you test for the presence of starch?
7. Name a herbivorous animal.
8. Why can a bear live all winter without eating?
9. What is a parasite?
10. Define a carnivorous animal.

WORK SHEETS.

After finishing this unit, you should know that:

I. Every living thing must obtain food in order to live.
II. All food is manufactured by green plants.
III. Organisms absorb food by the process of osmosis.
IV. Each organism has a special method for obtaining food.
V. Man takes advantage of the fact that plants store food for future use.

VOCABULARY

Photosynthesis—the manufacture of starch in green plants in the presence of light.

Parasite—an organism which obtains its food from another living organism.

Saprophyte—any organism which lives on dead organic matter.

REFERENCES

Bowden—426-427; 440-443; 448-454; 507-511.
Moon—65-73; 107-115; 159-165; 199-203; 310-312.
Smallwood—18; 43; 54; 132-137; 241-250; 455-459; 485-492.
Clement—46-47; 129-133; 323-326.
Wood & Carpenter, Book III—489-491; 493-501; 613-623.
Pieper & Beauchamp—76-82.

EXERCISES

Demonstration. With an apple corer, bore a hole a half inch wide, at least two inches into a large carrot. Fill the hole in the carrot with a fifty per cent solution of molasses. Fit a one-hole rubber stopper into the carrot with a glass tube so that the liquid shows in the tube above the cork and no air remains below the stopper.

(a) In what direction does the liquid flow? (b) What three things must be present if osmosis is to go one? (c) Compare the parts of the apparatus with those of a root-hair. (d) In what condition must a substance be in order to pass through an osmotic membrane. (e) Define osmosis.

Applications: 1. Why will putting salt around the roots of most plants kill them? 2. How do nutritions, excretion and respiration depend upon osmosis?

Exercise 2. (a) From where do green plants get their materials to make food? (b) What is the process by which a plant gathers food from the soil? (c) How does the water get from the root-hairs to the leaf? (d) On what does the seedling live before getting its leaves?

Demonstration. Pin thin layers of cork or blotter on both sides of a geranium leaf and allow it to stand for several days. (a) Explain results. Dip the leaf into hot water quickly and transfer to a beaker of warm wood alcohol until the leaf becomes white and then place it in a weak iodin solution. (b) Why does the leaf change color? (c) Compare.

Exercise 4. Compare the green leaf to a factory.

Exercise 5. Finish this table adding at least fifty other products placing each in the proper column:

ROOT	STEM	LEAF	SEED	FRUIT
turnip	potato	onion	wheat	banana

Exercise 6. (a) How do squirrels, woodpeckers, and butterflies or moths obtain their food? (b) Make a sketch of the mouth parts of each.

Exercise 7. (a) How does the amoeba obtain its food? (b) From a text or reference book, make a series of sketches to show this. (c) List at least four ways in which the paramoecium is a higher form than the amoeba.

Exercise 8. (a) Find the meaning of the following terms: carnivorous, herbivorous, omnivorous. (b) Using these three words and the words parasite and saprophyte as column headings, classify the following according to the kind of food eaten: 1. tick 2. bread mold 3. sheep 4. hookworm 5. toadstool 6. deer 7. man 8. tapeworm 9. goat 10. wheat rust 11. lion 12. cow 13. bed bug 14. mouse 15. typhoid bacteria 16. rabbit 17. lichen 18. hog 19. corn smut 20. cootie 21. tiger 22. yeast 23. mosquito 24. mushroom 25. flea 26. soil bacteria 27. horse 28. earthworm 29. potato beatle 30. wolf.

Exercise 9. (a) Bread mold will not grow on dry bread. Explain. (b) We sometimes find mold on the surface of canned fruits. How and when did it get there?

Exercise 10. Write a theme on the topic "How Living Things Store Food for the Future."

SUPPLEMENTARY EXERCISES.

Exercise 11. (a) In cultivating grains, from what kind of plants does the farmer select his seed? (b) Look in Bowden page 422 and make a list of the six most important cereals in the United States. (c) To what plant family do all cereals belong?

Exercise 12. Why is the "open season" for hunting game birds and wild animals most generally in the autumn?

Exercise 13. Demonstration—home experiment. Expose three pieces of bread to the dusty air for several hours and then place one in a very warm, dry place. The second piece should be placed in a cool damp place like a cellar or ice-box; and the third piece in a fruit jar with the lid screwed on. Explain your results.

Exercise 14. Plants are said to be good for living rooms, but bad for sleeping rooms. Explain.

Exercise 15. Prunes and raisins swell up when placed in water. Why? (b) When placed in salt water they shrink. Why?

Exercise 16. Name all the things man can do to help plants manufacture food.

Exercise 17. Explain completely how your food supply is dependent upon the sun.

TEST. UNIT III.

I. Value 21.

Fit one of the words to each of the seven definitions given below:

1. The lowest type of animal.
2. A plant or animal that lives on another living plant or animal.
3. The manufacture of starch or sugar by the use of sunlight.
4. An animal that eats nothing but plant food.
5. A plant that lives on dead organic matter.
6. An animal that feeds only on meat.
7. The process by which air passes through the walls of the lungs into the blood.

saprophyte	parasite	sponges	amoeba
carnivorous	osmosis	omnivorous	oxidation
photosynthesis	herbivorous	earthworm	secretion

II. Value 24.

Fill in the blanks so that each of the following statements is complete:

1. The paramoecium gives off carbon dioxide through the.....
2. Chlorophyll in green leaves aids in making.....
3. Iodin solution is used in a test for.....
4. Amoeba secures its food by the process called.....
5. A wolf is a.....animal.
6. In respiration, green plants use a gas known as.....

III. Value 16.

Mark here — Write the word *true* or *false* in the column to the left of the sentence.

1. Cells excrete waste by osmosis.
2. All animals have mouths.
3. Plants get their carbon from the air.
4. The fuel we burn all comes from plants.
5. A paramoecium is a simpler animal than an earthworm.
6. Bread mold is a parasite.
7. Grasshoppers obtain food by sucking the juice from leaves.
8. Man is an omnivorous animal.
9. The amoeba moves by means of cilia.
10. Many parasites carry serious contagious diseases.
11. We eat the root of the onion.
12. Carnivorous animals eat both flesh and plants.

13. Deer are classed as herbivorous animals.
14. Corn smut is a parasite.
15. Plants that do not have chlorophyll cannot manufacture food.
16. The part of the potato we eat is the seed.

IV. Value 21.

Underline the word or phrase which makes the best answer.

1. Plants obtain most of the materials for making food from the (a) soil (b) air and water (c) sunlight (b) minerls
2. Photosynthesis is the process of (a) storing food (b) transportation of food to all parts of the plant (c) making food by oxidation (d) food manufacture by green plants.
3. Water and minerals are taken into the plant by the (a) leaves (b) stems (c) root hairs (d) stomata
4. Osmosis is the process of (a) oxidizing food (b) of a thinner liquid passing through a membrane to a thicker liquid (c) transpiration (d) of a thicker liquid passing through a membrane to a thinner liquid.
5. Water and minerals must be transported from the (a) leaves to the roots (b) roots to the stems (c) leaves to all other green parts of the plant (d) roots to the leaves
6. The substance in a leaf which manufactures starch is (a) silver nitrate (b) Fehling solution (c) alcohol (d) chlorophyll
7. To manufacture starch, plants use two materials; water and (a) hydrogen (b) carbon monoxide (c) carbon dioxide (d) iodin

V. Value 18.

1. This diagram* represents an experiment to show.....
2. The contents of the carrot or egg correspond to.....
3. The egg membrane or carrot corresponds to what part in the plant.....
4. The water in the jar or glass corresponds to.....
5. The final level will reach a, b, or c. (encircle one)
6. A material must be in.....before it can pass through a membrane.

*A diagram of the osmosis demonstration experiment is used with part V of this test.

THIRTY PREHISTORIC PUEBLO VILLAGES FOUND IN ARIZONA.

Thirty new Pueblo sites have been unearthed in southeastern Arizona by Prof. Carl O. Sauer, of the geography department of the University of California.

The villages were all situated on the gentle slopes at the base of the mountains where the summer floods could be best utilized for farming. There has clearly been very little change in climatic conditions during the intervening centuries, Prof. Sauer reported.

The complete defenselessness of the location indicates that the Chiricahua Pueblos date back to a more peaceful period than do the walled towns of New Mexico. The houses were for the most part built with their floors two or three feet below the level of the ground, anticipating the pit houses of a later period.

A few of the Pueblo sites contain springs, but many are distant many miles from the nearest water. Prof. Sauer concludes from this that the villagers may have spent the dry spring months in the high mountains, returning to their towns with the summer rains.

The complete depopulation of these Chiricahua Pueblos appears to be due to the onslaught of savage tribes, rather than to famine.—*Science Service.*

AN UNBALANCED AQUARIUM FOR THE TEACHING OF BIOLOGICAL PRINCIPLES.

By D. F. MILLER,

Department of Zoology and Entomology, The Ohio State University, Columbus, Ohio.

The word "unbalanced" is not a misprint, it is correct. All students of biology are familiar with the balanced aquarium and most biology teachers have made and used it in their class work. The balanced aquarium does offer some good illustrations for ecological relationships but it seems not to have occurred to very many that the opposite, an unbalanced aquarium, has much greater teaching possibilities. This is especially true where the type of teaching used follows some plan of setting up problematic situations for the students, or of having the students discover and analyze the problems as far as possible for themselves, rather than where the type of teaching consists of the telling of facts to the class.

The best place to begin is with a simple balanced aquarium consisting of a goldfish and some aquatic plants. The whole general problem of gathering material and starting the aquarium may be turned over to the students (with guidance) unless time or location will not permit. If the class is large it may be divided into groups and several aquaria run simultaneously and a little rivalry added to increase interest. Even if the students are not trained or have not given the project previous thought they will be able to suggest some of the major problems involved in producing a satisfactory environment for a goldfish. This simple aquarium and its preparation presents some problems which really should be used as a foundation for the later work. The structural peculiarities of a fish are such as to fit it for living in water. But water alone is not sufficient, as some of the students will testify from their own attempts at keeping fish alive. The plants furnish food and help to "purify" the water. The word "purify" itself suggests a number of further problems about what plants do that purifies water. It is advisable not to add clams or snails as scavengers at first. Respiration, food supply, removal of pollution are easily balanced and the situation is uncomplicated so far.

As long as an aquarium remains balanced one has a fairly fixed set of conditions and relations, but as soon as it becomes unbalanced in one direction or another an entirely new set of conditions arise and with it a new chain of problems from which direct application may easily be made to all sorts of biological situations that exist in nature and in human society.

As soon as the ordinary balanced condition has been established the unbalancing may be begun. One might add five or six more fish and leave it to the students to anticipate any new problems. The addition corresponds to an increase in the population of a limited area. Obviously the balanced condition has been upset. It now presents anew the old problems of oxygen supply, food supply and pollution, and adds possible elimination of the less fit, cannibalism and reproduction. This may lead into a discussion of the organization of animal societies as, the family, herd, or colony, with division of labor and structural and intellectual differentiation.

Suppose now that the aquarium is still further unbalanced by the addition of a number of different kinds of animals, as tadpoles, frogs, insects, crayfishes, snails, leeches, and a small water turtle. These had best be added one kind at a time. Each addition brings about a further unbalancing and at once renews the old problems of food, oxygen and pollution, and introduces such new ones as, preying, commensalism, and parasitism. Any one of these subjects might be enlarged upon at great length. Let us consider parasitism as an illustration. Parasitism need not be treated superficially or dryly for the students may have an excellent chance to witness it. An adult frog is a splendid host. Excitement generally runs high in the class when they examine the lungs, stomach and intestines to find both roundworms and flatworms, not pictures in a book, not artificially colored material on a slide, not even a pickled specimen in a jar, but real living moving parasites attached in a natural way to a natural host and in their normal situations. If the intestine is opened and its contents mixed with a little water and mounted under a microscope protozoa and bacteria are nearly always present in abundance.

Certain kinds of fish, insects and crayfish are also good hosts. Life histories of parasites and alternation of hosts and the effects of parasitism upon the hosts can readily be illustrated. Congestion of population, pollution and preying are assets to parasitism.

Increase in population is associated with division of labor where we have physical differentiation as in the insects, and intellectual, as in man. Population is related to natural resources, labor, prosperity, unemployment, famine, immigration and emigration, birth rate, death rate and other problems.

Always, of course, the application might be made to natural conditions and to human society. Food, hunting, herding, animal husbandry, agriculture, economic pests and their control, public health and disease, sanitation and asepsis, care of the sick, survival of the unfit, feeble minded, criminal, insane; all these social problems are a part of biology.

All of them may not be directly illustrated in an aquarium but they are suggested by it. Some will offer the objections that many of these problems are social, and I will agree, but they are also biological problems and might well be approached from their true biological background instead of an emotional one as is too often the case.

A little consideration of the possibilities which this offers will convince the teacher of the vast extent to which the illustrations to be found in an unbalanced aquarium may be made to apply. The above scarcely scratches the surface of the storehouse of possibilities for the use of an unbalanced aquarium. How it may be used, the amount of detail called for, the complexity of the situations involved, may very easily be regulated by the size of the class or age of the students and the degree of advancement of the course.

The materials are common and inexpensive, and most of them can be brought in by the students. No pulling is necessary and the only ingenuity that the teacher needs is that of guiding and still remaining in the background as much as possible.

A SUCCESSFUL PROJECT PLAN IN CHEMISTRY.

By Miss S. Aleta McEvoy,
Senior High School, Rockford, Ill.

I have been successful in increasing the enrollment in my chemistry department over ninety percent in this past year, due to a project I started last year. I hope we will be able to finish it this year, but it is a problem that could keep us busy for five years if we had the time.

Being a firm believer in the project method of teaching (I suppose I should now call it the "unit system") I feel that the student should do at least one thing well. That is the reason that I started this type of teaching. I grow more enthusiastic about it every year.

Each student chooses some product that he or she wishes to manufacture, and keeps at it until he succeeds. The "joy of success" can never be described, you have to see the student to appreciate the joy he feels. Last year we started to build a *Chemical Home,* and we are still building. It is built to the scale of one inch to twelve inches, and everything in it must be built to that scale. The following articles have already been made: tar shingles, Magnesium cement for the bathroom floor, bathroom fixtures are clay, fired and glazed, linoleum for the kitchen floor, varnish, paint, glue, curtains and draperies, mirrors and floor lamps, insulators and a cement basement. In fact, we try to do some original work on everything that goes into the house. The process is slow for we have so little time, but the students are so happy, talking about the home.

There will be over one thousand shingles on it, so we must have a shingle party to finish cutting and dipping shingles. Only second semester pupils are working on the house, so my first semester pupils are eagerly awaiting their chance.

We made over forty-six different articles last semester. I have only one second semester class now so I do not have so many products being made, but so far this semester we have made hard rubber, a china doll's head, tanned hides, rose water and glue. I permit the students to work in groups this semester.

Perhaps you would like to hear about our Christmas

project. We are to have a *Chemical Christmas.* Every student is to look up one industrial process that goes into making Christmas time happy. They each make a poster showing the chemistry involved and place this poster on the wall. From each poster a ribbon will be run to the Christmas tree, and to some object on the tree made according to the process described. The first semester pupils will bring the commercial articles, but the second semester will bring the articles that they have manufactured. We are looking forward to a good time.

We are publishing a little newspaper every two months. We have just put out our first number and sold one hundred and sixteen copies, just to the chemical students. It was really a student edition for they planned everything.

We belong to the Junior Academy of Sciences and the students put on a club program every two weeks during recitation period. They love to do things.

A laboratory lunch is interesting. The students clean up their glass ware and cook their lunch in the laboratory.

The students are always interested in the work of the other students, so their interest extends beyond their own project. They have learned by observing as well as by doing.

NEW METHOD FOR MAKING COAL GAS.

A new, time saving method for making coal gas was described by Prof. Alfred H. White of the University of Michigan department of chemical engineering. Prof. White directed experiments which have covered a considerable period of time.

The process generally used in most sections of the country involves loading giant retorts with coal and heating the retort until the coal is slowly baked. The baking converts the coal to coke at the rate of a few inches an hour. The gas resulting from the conversion is stored for subsequent distribution through the gas mains.

The new method uses all the materials and apparatus of the old method. However, the coal first is pulverized in the new scheme. The powdered coal then is delivered into retorts which previously have been heated until their sides glow with a bright red color.

The conversion of coal to coke was said to be almost immediate when the powdered coal came in contact with the superheated air within the retorts. The resultant gas production is also immediate.

The experiments were done at the behest of a large gas organization, he said. Only a part of the work was done in the laboratory, the final operations being carried out in an actual gas plant on a large scale.—*Science Service.*

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,

Illinois State Normal University, Normal, Ill.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

LATE SOLUTION.

1127. *H. E. Williams, Ironton, Ohio.*

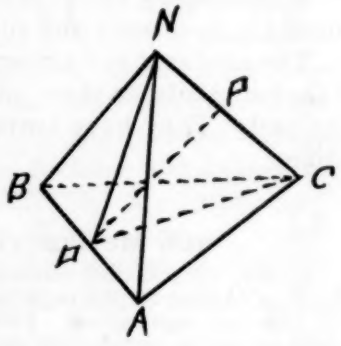
SOLUTIONS OF PROBLEMS.

1133. *Proposed by Mildred E. Collins, Newburyport, Mass.*

What is the value of the dihedral angle of a regular tetrahedron? Can the problem be solved without the use of trigonometry?

Solved by W. E. Buker, Leetsdale, Pa.

Let e be the edge of the tetrahedron; D the midpoint of AB; P the midpoint of NC.



Then $DC = DN = e\sqrt{3}/2$. The number of degrees of the dihedral angle is the same as the number of degrees in the plane angle NDC. The plane NDC determines an isosceles triangle whose sides are $e\sqrt{3}/2$, $e\sqrt{3}/2$, and e. Hence, $PC : DC = 1 : \sqrt{3}$. This means that sin PDC = .577, from which we get (using tables) $\angle PDC = 35°16'$. Therefore, $\angle NDC = 70°32'$.

Also solved by *Clyde Bridger, Walla Walla, Wash.* A solution by Descriptive Geometry was received from *Sudler Bamberger, Harrisburg, Pa.*

Editor.—I am convinced that this problem cannot be solved by analysis without the use of trigonometry.

1134. *Proposed by Louis R. Chase, Newport, R. I.*

Find the whole numbers whose digits from left to right are a, b, c, d, each of which is greater than unity, and satisfy the following equations: (1) $a^2+2bc+d^2=77$ and (2) $b+c=2ad$.

Solved by Marge Joseph, Milwaukee, Wis.

Since $a^2+2bc+d^2=77$ and $b+c=2ad$, $(a+d)^2=77-2bc+b+c$ and $a+d=\sqrt{77-2bc+b+c}$.

We are not able to solve directly 2 equations having 4 unknowns, we use a method of trial by substituting values of b and c until the number under the radical sign is a perfect square

If $b=4$ and $c=8$, or $b=8$ and $c=4$, the radicand is a perfect square. Substituting these values of b and c in the original equations, we have $a^2+d^2=13$ and $2ad=12$. Whence, $a=2$ or 3 and $d=3$ or 2. Hence the numbers are 2483, 3482, 2843, and 3842.

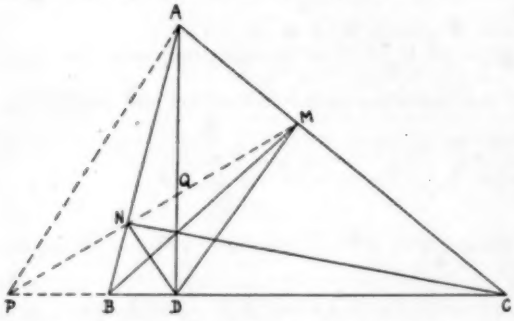
Also solved by *W. E. Buker, Leetsdale, Pa.; Hazel Fliess, Clifton Forge, Va.; A. J. Patterson, Wheeling, W. Va.;* and *George Sergent, Tampico, Mexico.*

1135. *Proposed by W. E. Buker, Leetsdale, Pa.*

(Taken from College Geometry, Altshiller-Court).

If in a triangle ABC the lines BM, CN intersect on the altitude AD, then AD is the bisector of the angle MDN.

Solved by Louis R. Chase, Newport, R. I.



Let MN meet CB at P.

PC · NB · MA = PB · NA · MC

(*Menelaus' Theorem.* Any line cuts the sides of a triangle so that the product of three non-adjacent segments equals the product of the other three.)

DC · NB · MA = DB · NA · MC

(*Ceva's Theorem.* Three concurrent lines from the vertices of a triangle divide the opposite sides so that the product of three non-adjacent segments equals the product of the other three.)

From the above, PC : PB = DC : DB, thus BC is divided harmonically.

Therefore the four lines from A constitute a harmonic pencil.

Therefore P, Q, N, M constitute a harmonic range.

Therefore DP, DQ, DN, DM constitute a harmonic pencil.

Therefore AD bisects angle MDN. (If one pair of conjugate rays of a harmonic pencil are at right angles to each other, they are the external and internal bisectors of the angle between the other two.)

In case MN is parallel to BC, it is easily shown by similar triangles that NQ : QM = QM : NQ, hence NQ = QM, AD is the perpendicular bisector of NM, and DN, DM make equal angles with AD.

Also solved by *Guy C. Lentini, Boston, Mass.; George Sergent, Tampico, Mexico; W. E. Baltzer, Battle Creek, Mich.; A. J. Patterson, Wheeling, W. Va.;* and the *Proposer.*

1136. *Proposed by A. A. Shaw, University of Arizona.*

Prove that the product of any three consecutive integers is a multiple of 504 if the middle integer is a perfect cube.

Solved by Louis R. Chase, Newport, R. I.

Our product $(n^3-1)\ (n^3)\ (n^3+1)$, equals

$$(n-1)\ (n^2+n+1)\ n^3\ (n+1)\ (n^2-n+1).$$

We shall show that at least one of these factors must be divisible by 7, one by 8 and one by 9, whose product is 504.

If x be any positive integer, all values of n are included below.

$n = 7x$.

$n = 7x+1$, whence $n-1 = 7x$.

$n = 7x+2$, whence $n^2+n+1 = 49x^2+35x+7$.

$n = 7x+3$, whence $n^2-n+1 = 49x^2+35x+7$.

$n = 7x+4$, whence $n^2+n+1 = 49x^2+63x+21$.

$n = 7x+5$, whence $n^2-n+1 = 49x^2+63x+21$.

$n = 7x+6$, whence $n+1 = 7x+7$. Thus in every case 7 is a factor of the product.

Again, $n = 2x$, whence $n^3 = 8x$.

$n = 2x+1$, whence $n-1$ and $n+1$ are consecutive even numbers, hence their product is divisible by 8.

Finally, $n = 3x$, whence $n^3 = 27x$.

$n = 3x+1$, whence $n^3-1 = 27x^3+27x^2+9x$.

$n = 3x+2$, whence $n^3+1 = 27x^3+54x^2+36x+9$. Thus the product is also divisible by 9.

Also solved by *Winnona Venard, Lawrence, Kansas; W. E. Buker,*

Leetsdale, Pa.; Wilfred F. Kruse, Seward, Neb.; Marge Joseph, Milwaukee, Wis.; W. E. Baltzer, Battle Creek, Mich.; A. J. Patterson, Wheeling, W. Va.; and the *Proposer.*

1137. *Proposed by Norman Anning, University of Michigan.*

Find integers n and r such that ${}_nC_{r-1}$, ${}_nC_r$, and ${}_nC_{r+1}$ shall be in arithmetical progression.

Solved by A. J. Patterson, Wheeling, W. Va.

Since the three expressions are to be in arithmetic progression, we have

$${}_nC_{r-1} - {}_nC_r = {}_nC_r - {}_nC_{r+1}.$$

Setting up the general expression for each combination and simplifying we get

$$4r^2 - 4rn + n^2 - n - 2 = 0.$$

Whence, $r = \dfrac{n + \sqrt{n+2}}{2}$

Selecting values of n which make $\sqrt{n+2}$ a square, we know the smallest value is 7. Therefore, $r = 2$ or 5.

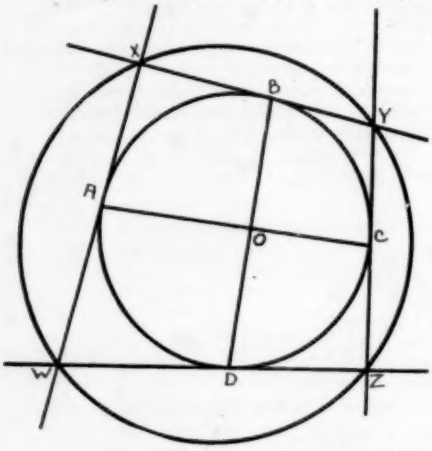
Then ${}_7C_4 = 35$, ${}_7C_5 = 21$, ${}_7C_6 = 7$.

Also solved by *Albert Schwartz, Perth Amboy, N. J.;* and *Louis R. Chase, Newport, R. I.*

1138. *Proposed by R. T. McGregor, Elk Grove, Calif.*

A quadrilateral is inscribed on one circle and circumscribed about another. Show that the straight lines joining opposite points of contact of the in-circle are at right angles.

Solved by W. E. Baltzer, Battle Creek, Mich.



To prove BD $\perp$ AC.

Proof. 1. $\angle$BYC is measured by ½ (arc BAC − arc BC)
$\angle$AWD is measured by ½ (arc ABD − arc AD)

2. $\angle BYC + \angle AWD = \frac{1}{2}$ [(arc BAC − arc AD) + (arc ABD − arc BC)] = ½[(arc AB + arc DC) + (arc AB + arc DC)] = ½ (2 arc AB + 2 arc DC) = arc AB + arc DC.

3. $\angle BYC + \angle AWD = 180°$ (Opposite angles of an inscribed quadrilateral are supplementary.)

4. Therefore, arc AB + arc DC = 180°.

5. $\angle$BOA is measured by ½ (arc AB + arc DC). Hence equal to 90°. Then $\angle$BOA is a rt. $\angle$, and BD is $\perp$ to AC.

Also solved by *Charles Burgener, Louisville, Ky.; Guy C. Lentini, Boston, Mass.; Bert Norbert, Trinity H. S., Chicago, Ill.; W. E. Buker, Leetsdale, Pa.; A. J. Patterson, Wheeling, W. Va.; Katherine West, Sioux City, Iowa;* and *George Sergent, Tampico, Mexico.*

PROBLEMS FOR SOLUTION.

1151. *Proposed by I. N. Warner, Platteville, Wis.*

A farmer bought a straight-up open top rectangular tank measuring 3 ft. 6 in. wide and 5 ft. 6 in. long (inside measure). It was brought home

and placed in a level position. During a shower of rain, 3 gallons of water were caught in the tank. What depth of rainfall was that shower?

1152. *Proposed by S. Chuang, Ping-yang-fu, Shansi, China.*

Surd numbers can be expressed as a series of rational fractions. Prove that

$$\sqrt{2}=1+\tfrac{1}{2}-\frac{1}{2\text{x}5}+\frac{1}{2\text{x}5\text{x}7}-\frac{1}{2\text{x}5\text{x}7\text{x}197}+\cdots\cdots$$

1153. *Proposed by I. N. Warner, Platteville, Wis.*

(Taken from Macnie's Geometry, page 187, Ex. 499)

C is the center of a circle. On any diameter take two points, as O and Q, equidistant from C. If through one of these points, a chord be drawn, as AB and then A and B be connected with Q, then the sum of the squares of the sides of the triangle thus formed is constant.

1154. *Proposed by the Editor.*

A weather vane on a ship's mast points northeast when the ship is headed due east at 16 miles per hour. If the velocity of the wind is 20 miles per hour, what is the true direction of the wind?

1155. *Proposed by Louis R. Chase, Newport, R. I.*

Given the line of the base, midpoint of base, vertex angle; to construct the triangle. A geometrical solution is desired.

1156. *Proposed by E. de la Garza, Brownsville, Texas.*

A father and his son work together. The father, after a certain number of working days, receives a total pay of $72. The son, having worked 5 days less, receives $50. If the son had worked as long as the father, and if the father had worked 5 days less, they would have received the same total pay. Find the number of days that each worked and the wage per day.

PACK FELLOWSHIPS WILL TRAIL FORESTRY LEADERS.

Eight fellowships for the training of leaders in forestry have been awarded for the year 1930-31 by the Charles Lathrop Pack Forest Education Board, and the Board is preparing to receive applications for fellowships for the year 1931-1932. The fellowships already granted cover a wide range of practical and theoretical forestry, including reforestation, management of private forest estates, cooperative marketing of forest products, silvicultural management, and forest pathology.

Six to eight fellowships, with stipends ranging from $500 to $2,500, are available for the coming year. The purpose of the fellowships is to encourage men who have shown unusual intellectual and personal qualities to obtain training that will best equip them for responsible work, either in the general practice of forestry, in the forest industries, in the teaching of forestry, in forest research, or in the development of public forest policy.

Awards will be made to gifted men who demonstrate natural powers of intellectual and personal leadership and who intend to make forestry their life work. Special emphasis will be placed on character, intellect, imagination, initiative, industry, resourcefulness, adaptability, ability to deal with men, ability to assume responsibility, and personal interest in forestry. The fellowships will ordinarily be restricted to men of American or Canadian citizenship.

Applications will be received not later than January 15, 1931. Application forms and detailed announcements can be obtained from Ward Shepard, Secretary of the Charles Lathrop Pack Forest Education Board, 1214 Sixteenth St., N. W., Washington, D. C.

REPORT OF THE ANNUAL MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INC.

Lincoln High School, Milwaukee, Wis., Nov. 28 and 29, 1930.

The program of the thirtieth meeting of the Central Association of Science and Mathematics Teachers was carried out as announced in the November, 1930, issue of SCHOOL SCIENCE AND MATHEMATICS, but with the addition of an address by Professor Warren Weaver of The University of Wisconsin on "The Structure of the Atom."

The attendance at all the sessions was unusually large. The apparatus and book companies put on good displays of their newest products. The exhibits of the work of the Milwaukee schools showed that Milwaukee teachers are making use of all modern approved methods of teaching.

The report of the President, the Treasurer, and the section reports are given on the following pages. Many of the papers read at these meetings will be published in later issues of this journal.

The officers elected for 1931 are: President: Glen W. Warner, Crane Junior College, Chicago, Ill.; Vice President: Katherine Ulrich, Oak Park—River Forest Twp. High School, Oak Park, Ill.; Secretary: W. F. Roecker, Boys' Technical High School, Milwaukee, Wis.; Treasurer: Ersie S. Martin, Arsenal Technical High School, Indianapolis, Ind.; Directors for Three Year Term (1930-1933): Walter W. Hart, The University of Wisconsin, Madison, Wis.; H. Clyde Krenerick, North Division High School, Milwaukee, Wis.; Christine K. Fuchs, Hyde Park High School, Chicago, Ill.; G. B. Eisenhard, Culver Military Academy, Culver, Ind.—Extracts from the report of Marie Sangernebo, Assistant Secretary.

PRESIDENT'S REPORT.

The position of President of this Association is not exactly a sinecure. Serving in that capacity for a year increases the respect in which a president holds his predecessors; however, the work and troubles are not the most prominent features of the position. The privilege of association with the members and clientele is a fine one, also the honor which comes to the head of such a group of people, as is found in this association, is one worthy to be sought by anyone

As President, I feel that I have received the heartiest cooperation and support, first, from my predecessors in office, a support which meant instructions in my duties and the guarding against possible pitfalls, second, from the present officers all of whom have been more than willing to assume their fair share of the responsibility of this association, third, from the membership itself, which I have come to know well and all of whom have been ready to accept tasks in connection with the program when called upon, and lastly, from the friends of the association, our advertisers, and exhibitors.

This is an "off" year for business enterprise, and I presume that many of our advertisers would have been willing to forego the expenses had it not been for their loyalty to the association. In commenting on carrying out the duties of my office it would be unfair for me not to mention the Printing Department of Washington High School which stood ready to do our small jobs of printing and for which we have paid only the cost of materials involved, the Commercial Department which has carried on much of my correspondence, organized and filed it, and which addressed and mailed the six thousand Year Books, and my two stenographers who in addition to their regular duties have carried on a rather voluminous correspondence in connection with the program and the Year Book. I do not see how a person less fortunately situated with respect to help of this sort would be able to fill this position and do much else.

As is evident from the program, we have attempted to unify our Sectional and General programs around the topic of "Teaching Units." In securing speakers for the General program we have commanded the services and influence of several of our members without whose assistance the task would have been well-nigh impossible. I want especially to mention Mr. Walter Hart in this connection. Besides giving me good advice he has been instrumental in securing some of the best speakers available in the University of Wisconsin for our program.

Having been treasurer of the assocation in recent years and having witnessed a gradual diminishing of the funds of the association, we have sought to make this an economy administration. How well we have succeeded will not be evident until the bills of the year have been paid. We have, however, paid no spakers on our program; the travelling expenses of non-members appearing on the General program are being paid; the advertising in the Year Book, if all collected should total $701.00; advertisers have been billed and some of them have already paid; the cost of printing is $538.50; postage on the Year Books $92.15 and envelopes for mailing the Year Books $16.40, making the total cost of the Year Books $647.50. The Year Book has, therefore, paid for itself. Other items in my expense account amount to $27.10.

I appreciate the honor of having served in this capacity, and I am sure in future years I will look back upon it with certain pleasure if not satisfaction.

W. G. GINGERY.

TREASURER'S REPORT.

November 22, 1929—November 24, 1930.

Receipts:

641 Memberships (Direct) at $2.50	$1,602.50
182 Memberships (Through Mr. Roecker) at 50c	91.00
Exchange	.45
Advertising 1930 Year Book	34.00
Income 1929 Year Book	10.86
Total Receipts	$1,738.81
Balance on hand Nov. 22, 1929	298.57
	$2,037.38

Disbursements:

641 Subscriptions to S. S. and M. at $2.00	$1,282.00
Speakers (1929)	147.54
Annual Meeting	79.96
Miscellaneous	254.96
Total Expenses	$1,764.46
Balance on hand Nov. 24, 1930	272.92
	$2,037.38

ERSIE S. MARTIN, Treasurer.

This is to certify that I have audited the accounts of the Treasurer of the Association, Mr. Ersie S. Martin, and have found them correct.

Respectfully submitted,

WALTER H. CARNAHAN.

REPORT OF THE BIOLOGY SECTION.

The annual meeting of the Biology Section was held Friday afternoon, November 28, in the Lincoln High School. There were about fifty members present. A nominating Committee consisting of W. H. Atwood, Susan M. Farris and C. D. Johnstone was appointed by the chairman of the Section.

Dr. William G. Vinal, Professor of Nature Education at Western Reserve University gave an illustrated lecture on the subject of "Humanizing the Teaching of Biology." He would have the Biology Teacher plan his course so that it would fit the life activities of the child. The camping experiences common these days to many of the boys and girls of high school age have caused an increase in the interest in Biology. Students who have not had such experiences need to know more about living things than they can find in books and preserved specimens. Dr. Vinal appealed for a better knowledge of our home environment and a willingness on the part of the teacher of Biology to acquaint his pupils with their neighbors.

All who attended the convention were impressed with the exhibition on Conservation. Mr. H. J. Parmley told the section of the work done by the Faculty Conservation Committee of the Boys Technical High School. An appeal was made for Leadership in Conservation Education. Action on this appeal was taken by ordering the chairman to appoint a committee to draft a suitable resolution requesting action by the association. This resolution was passed at the Business Meeting Saturday morning. The president was authorized "to appoint a commttee to consider subject matter, methods of procedure, necessary curricular adjustments, and to present at the earliest practicable date proposals or plans for extension of conservation education in the high schools of the land."

The report of the nominating committee of the Section was made by the chairman W. H. Atwood and the following officers were elected for the coming year: Chairman, Grant Cook, Harrison Technical High School, Chicago; Vice-Chairman, H. A. Severy, South Division High School, Milwaukee; Secretary, Mabel E. Smallwood, Lane Technical High School, Chicago. The election of officers concluded the business of the meeting.

J. W. HADLEY.

REPORT OF THE CHEMISTRY SECTION.

The meeting of the Chemistry Section of the Central Association of Science and Mathematics Teachers was held in Room 112 of the Lincoln High School, Milwaukee, Wis., Friday, Nov. 28, at 1:30 p. m. Mr. G. T. Franklin of the Lane Technical High School, Chicago, Chairman of the Section, presided.

Mr. Ira Davis, of the Wisconsin High School of the University of Wisconsin, presented a very interesting paper upon "Providing for Individual Differences." He explained the three contrasts given to the student and the part that the pupils and teacher took in each.

Mr. Fred G. Anibal, Head of the Science Department, The University High School, University of Chicago, gave a talk on "The Unit Method Applied to High School Chemistry." He stressed the need of holding the interest in Science, instead of killing it as seemed to be general now. He presented some objections in teaching and showed how the so called "Unit Method" tried to meet the objectives.

Mr. J. O. Frank, Oshkosh Teachers College, Oshkosh, Wis., gave the results of some studies worked out by his pupils. He gave some of the things that teachers felt that they needed most help to present. Then he showed how this need was met by various chemistry journals. He also gave a comparison of the materials found in text books of the past and present.

The report of the Nominating Committee, consisting of Mr. Gordon M. Brown, Dr. McLeod and Mr. C. D. McLouth was then called for. They reported as follows: Mr. Harry T. Blair, South Division High School, Milwaukee, Wis., Chairman; Mr. Fred G. Anibal, University High School, Chicago, Ill., Vice Chairman and Miss Mary A. Doherty, Kenosha Senior High, Kenosha, Wis. Secretary.

The meeting was of great interest and value to all who attended.

MARY A. DOHERTY, *Secretary.*

REPORT OF THE GEOGRAPHY SECTION.

Officers: Chairman, Miss Katherine Ulrich, Oak Park-River Forest Township High School, Oak Park, Ill.; Vice Chairman, Mr. W. O. Beckner, Elgin High School, Elgin, Ill.; Secretary, Miss Villa B. Smith, School of Education, Western Reserve University, Cleveland, Ohio.

The meeting was called to order by the president in the assembly hall of Lincoln High School, Milwaukee.

A nominating committee was appointed. This committee consisting of Mr. Thomas H. Finley, Austin High School, Chicago; Mr. Clinton Rich, Roosevelt Junior High School, Milwaukee and Miss Edna Ison, Steuben High School, Milwaukee, presented the following names: Chairman, Miss Helen Turner, Oak Park-River Forest Township High School, Oak Park, Ill.; Vice Chairman, Miss Villa B. Smith, Western Reserve University, Cleveland, Ohio; Secretary, Miss Alice Hahn, Proviso Township High School, Maywood, Ill.

The committee report was accepted and the officers elected by unanimous vote of the group.

Mr. James H. Smith, Austin High School, Chicago, spoke briefly concerning conservation and urged that the Section go on record as supporting the program outlined by the Conservation Committee of the Boy's Technical High School, Milwaukee.

Mr. Clinton Rich, Roosevelt Junior High School, Milwaukee, moved that the Geography Section heartily endorse the work of conservation in every way possible. Motion was seconded and carried.

The topic, "Vitalizing the Teaching of Geography" was most ably presented by Miss Alice Hahn, Proviso Township High School, May-

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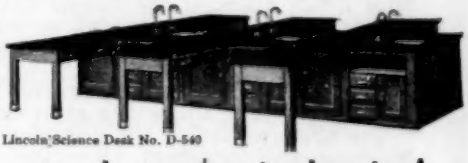

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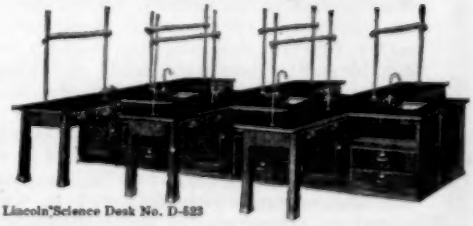

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wood, Illinois. Copies of lesson units were distributed. A ten minute discussion period followed the presentation of the paper.

"Urban Geography of Milwaukee" was presented by Dr. Loyal Durand, Department of Geography, University of Wisconsin. Dr. Durand took the group, via bus, to typical districts in residential, industrial and commercial areas. Here he called attention to the adjustments man has made, and emphasized geographic relationships.

The trip required two and one-half hours and was enjoyed by a group of twenty-eight.

VILLA B. SMITH, *Secretary.*

REPORT OF THE GENERAL SCIENCE SECTION.

The General Science Section held its meeting in the General Science room in the Lincoln Hgh School. Mr. C. L. Thiele of Detroit, chairman, presided. The other officers present were W. L. Beauchamp, vice-chairman and Ira C. Davis, secretary. A nominating committee consisting of Miss Weber of Madison, Mr. Mayfield of Chicago and Mr. Phillips of West Allis was appointed. Upon their recommendation, the following officers were elected for 1931:

W. L. Beauchamp, Chairman, University High School, Chicago.

Ira C. Davis, Vice Chairman, University High School, Madison.

Paul G. Edwards, Secretary, Supervisor of Science, Chicago.

The following program was given:

G. A. Bowden: Teach Laws and Principles to Increase Interpretation.

Paul G. Edwards: The Assignment As Developed by the Supervising Staff and Teachers of Chicago.

Dennis C. Haley: Demonstration of Units in Science as Developed in the Schools of Boston.

W. L. Beauchamp: A Circle Test, How It is Constructed.

An enthusiastic discussion followed the program. Many fruitful questions were asked. The speakers were given further opportunity to defend their papers and to answer the questions. It was one of the most interesting and worthwhile meetings held by the General Section in many years.

IRA C. DAVIS, *Secretary.*

REPORT OF THE MATHEMATICS SECTION.

The Mathematics Section of the Central Association of Science and Mathematics Teachers met Friday afternoon, Nov. 28, 1930.

In the absence of the chairman, Mr. James W. Hoge, of Oakland, California, the meeting was called to order by the vice chairman, Miss Edith Atkin, of the Illinois State Normal University, Normal, Illinois. Miss Atkin appointed as nominating committee:

Mr. Edwin W. Schreiber, Western State Teachers College, Macomb, Illinois.

Miss Martha Hildebrandt, Proviso High School, Maywood, Illinois.

Mr. W. W. Hart, University of Wisconsin, Madison, Wisconsin.

The first speaker on the program was Mr. Allison B. McCain of Washington High School, Milwaukee, who read an interesting paper on "Aims, Purposes, and Methods in High School Trigonometry." After briefly sketchng the history and nature of trigoncmetry, he considered in detail the aims and purpose of such a course—whether the practical or theoretical aspect should be emphasized. Heads of the departments of mathematics of several universities, who were consulted, varied greatly in their opinions; one thought that no theory should be taught, another believed in stressing both phases, the others wished the main emphasis to be placed upon theoretical work. In the discussion which followed it was said that this was the first paper on trigonometry to be given in the history of the Association.

Dr. John P. Everett, Western State Teachers College, Kalamazoo, Michigan, presented an able paper on "New Type Tests in High School Mathematics." After contrasting the new-type examination with the essay form, he said that the chief function of the new-type test is to shed light on determining the objectives of education, that it fills a distinctve need in providing a method for detailed diagnosis and for showing relationships. He recognized these tests as a step in educational progress, but not as the ultimate goal which they are sometimes considered; and warned against dangers of standardization and a blind dependence upon statistics.

"The Unit in Mathematics" was skillfully presented by Dr. E. R. Breslich, School of Education, University of Chicago. The unit idea, he said, is not new but has been long used by teachers and writers and with varying meanings. He defined the unit in mathematics as the unifying principle. The facts in the unit must be closely related, and this relationship must be evident to the pupil as well as to the teacher; the purpose and the objectives of the unit should be known to both; there should be a minimum which each pupil must master; a test should be made before the unit is begun instead of after the unit is finished.

Dr. Charles A. Stone, University High School, University of Chicago, as chairman of the committee on "A Combined Course in Plane and Solid Geometry," presented its report. A questionnaire about Solid Geometry sent to many schools, showed that the majorty believed that solid geometry should be taught, but by a 3 to 1 vote they opposed combining both plane and solid geometry in a one year course.

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He, and Prof. W. W. Hart, another member of the committee, told of some experiments they had made in their own classes in infusing related topics in plane and solid geometry. Their experiments showed that a fusion could be made; the question of the desirabilty of this procedure remains unanswered. They urged that further experiments be performed by others with the work carfully directed. It was suggested that the incoming chairman appoint a committee to continue this study during the next year.

The following report of the nominating committee was read by the chairman, Mr. Schreiber, and unanimously adopted:

Chairman, J. J. Johnson, Chicago Normal College, Chicago.

Vice Chairman, A. B. McCain, Washington High School, Milwaukee.

Secretary, Mary A. Potter, Supervisor of Mathematics, Racine, Wis.

A motion was made and carried that the secretary be instructed to write Mr. Hoge an appreciaton of the excellence of the program he had prepared.

MARY A. POTTER, *Secretary.*

REPORT OF THE PHYSICS SECTION.

The meeting was called to order by Chairman H. Clyde Krenerick. The program was then carried out as follows:

"What to Teach in Radio," by Elmer E. Burns, Chicago, Ill.

"Light Ray Reproduction of Sound," by A. H. Gould, Milwaukee, Wis.

"The Teaching of Problems in Physics," by Ira C. Davis, Madison, Wis.

"A Demonstration in Spectrum Colors," by C. L. Truesdale, St. Louis, Mo.

"Caring for Individual Differences in Physics," by Karl Evert, Marinette, Wis.

"An Experiment in Conducting Tests," by Ernest L. Hays, Hammond, Ind.

"Polarization of Radio Waves," by R. J. Suchy, Lincoln High School, Milwaukee, Wis.

"The Physics Club as an Aid to the Class Room Teaching," by H. S. Drake, Washington High School, Milwaukee, Wis.

"Exceptional Characteristics of Iron When Heated," by J. W. Schenck, Riverside High School, Milwaukee, Wis.

"Newton's Second Law of Motion," by Gideon Karlson, North Division High School, Milwaukee, Wis.

"Practical Equipment for Radio Demonstration," by D. L. Barr, Township High School, Mt. Pulaski, Ill.

The nominating committee, of which A. J. Wilbur of Racine acted as chairman, presented the following as officers for the ensuing year. The report was accepted by vote of the section: Chairman, H. G. Burns, Marshall High School, Chicago; Vice Chairman, C. H. Walter, Central High School, Kenosha, Wis.; Secretary, F. M. Carl, Collinwood High School, Cleveland, Ohio.

The meeting was then adjourned.

Respectfully submitted,

C. H. WALTER, Secretary.

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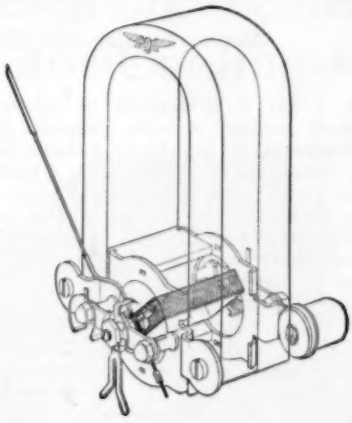

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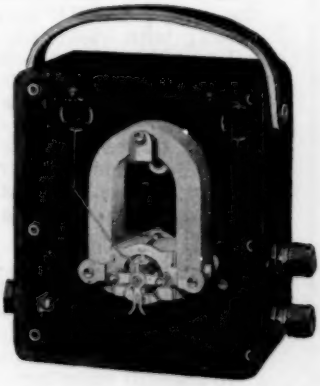

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A REQUEST FROM SWEDEN

568. *Mr. Lorens Carlsson, Malmo, Sweden, sends the following letter:*

Malmo, Sweden, the 22d of Oct. 1930.

Mr. Franklin T. Jones,
Cleveland.

Since two years I am a subscriber to SCHOOL SCIENCE AND MATHEMATICS and have studied it with greatest interest. Especially the tests and examination questions I have read carefully in order to find out the claims on a pupil at an American high school. But I know too little about organization, methods a. s. o. at those schools. Will you be so kindly to recommend a book to me which contains matters about such things and—if possible—try to find a teacher in mathematics and physics, who are interested by correspondence in mentioned purpose.

Yours sincerely

LORENS CARLSSON,
Malmo, Sweden, Ryttmastaregatan 3b.

Will the teachers who are willing to correspond with Mr. Carlsson write to him direct and also send their names to me?—Editor.

WHO IS THE MAN?

569. *Proposed by A. C. Norris, McClure, Ill.*

(Please refer to page 964, SCHOOL SCIENCE AND MATHEMATICS, November, 1930, and re-read Mr. Norris' letter. Then send the Editor the name of THE man in your community who might be willing to help with questions. *Editor.)*

I would write to some leading man in his profession asking him to submit from 15 to 30 questions covering their field of activity along the line of Science, both physical and biological.

Dear Dentist: Give me 25 questions covering the field of dentistry.

Dear Criminal Lawyer: Submit 20 science questions you would ask a young man entering your office as apprentice.

Dear Blacksmith: A boy wishes to enter your shop; give me 20 questions he should be able to answer about iron, steel, fuels and related topics.

570. *Proposed by "A Science Teacher."*

On page 896 of October, 1928, SCHOOL SCIENCE AND MATHEMATICS I find the following interesting paragraphs:

Present day standardized tests owe their vogue, principally, to the fact that (1) the publishing houses advertise and boost them; (2) prominent educators make money out of them; (3) they are a new idea in tests; (4) they are so much easier for teachers to grade; (5) they are much more accurate than older types of tests.

"The mere presence of the fifth choice among the others, is almost a dead give-away. But if the fifth choice is changed to (5) none of these, then the excellent quality of the fifth choice as compared with the others is not present. The question would then be as follows:—

"Present day standardized tests owe their vogue, principally, to the fact that (1) the publishing houses advertise and boost them; (2) prominent educators make money out of them; (3) they are a new idea in tests; (4) they are so much easier for teachers to grade; (5) none of these.

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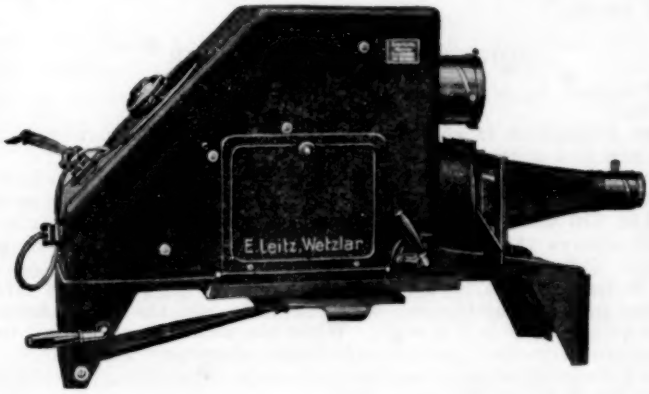

The four parabolic mirrors which act as concentration medium for the light rays, lend the Projector "Vh" a *most effective mode of light concentration resulting in an exceedingly brilliant and white image at the screen.* The four mirrors cast the light upon the opaque object in an evenly distributed manner, *eliminating the possibility of shadows and uneven objects.* The ventilator-cooling-system continuously blows cool air upon the object and thus specimens can be handled conveniently and injury to them through overheating is eliminated. The projection objectives are of utmost correction, *giving crisp and clear-cut images.*

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not really know why standardized tests are used, would then be more likely to pick one of these choices."

Is the fifth choice a dead give-away or is the fourth choice the real reason for the popularity of the new type tests? Is it not true that one of our principal reasons for adopting the new type tests is their high correlation with tests of the essay type and the time gained in scoring? This reason has two factors, reliability and time saved in scoring. Either of these alone would have killed the new type tests in infancy; the combination of the two factors has made these tests sturdy youths but many teachers still doubt that they will ever live to maturity. I make much use of these tests but much of it is because I am forced to mass production and not because I am convinced that they are always either the best teaching devices or the most accurate means of determining the progress or knowledge of pupils.

JOHN SKOK ASKS ANOTHER.

567. *Proposed by Mr. John Skok, Chicago, Ill.*

Mr. Jones:

I have a question in electricity which I would like answered, as I understand you give such discussions in the journal.

In our laboratory work in physics we use a D. C. line which is generated by a D. C. generator in the school. On the switchboard it is marked 110 volts and also 220 volts, although our voltmeter readings are always 110 volts or two or three volts either more or less, but never 220. The switch on the switchboard has three contact points instead of two, and I was told that the P. D. of the middle conductor and an outside one was 110 volts, but the P. D. between the two outside ones is 220 volts. When the switch is closed, all three of these are connected, yet the voltmeter only shows 110 volts.

I don't understand this nor how one generator can generate both 110 and 220 volts at the same time.

Yours very truly,

JOHN SKOK.

Answer and the Other Question.

571. *Proposed by John Skok, Chicago, Ill.*

Dear Mr. Jones:

I received your letter and in the meantime have learned something of these three pole circuits and have an idea of the principle.

The plate reading on the dynamo is as follows:

125 volts and 125 volts; 1000 amp. and 250 volts; 150 amp. in neutral; 250 Kw.

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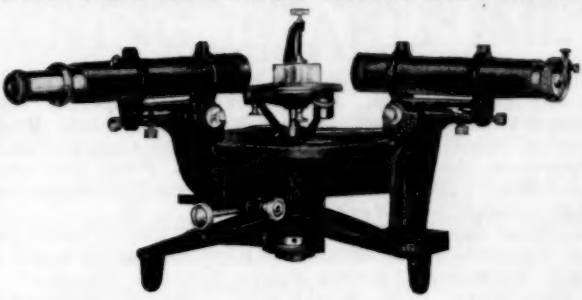

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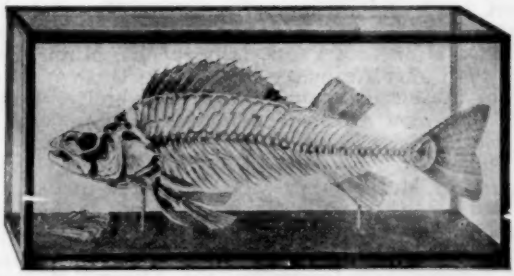

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BOOKS RECEIVED.

Experimental Chemistry by A. Frederick Collins, F. R. A. S. Illustrated by the Author. Cloth. Pages xvii + 276. 12.5x18.5 cm. 1930. D. Appleton & Company, 35 West 32nd Street, New York. Price $2.00.

Elements of Plant Science by Charles Joseph Chamberlin, Professor of Botany in the University of Chicago. First Edition. Cloth. Pages xii + 394. 14x20.5 cm. 1930. McGraw-Hill Book Company, 370 Seventh Avenue, New York. Price $1.90.

Examinations Seventy-Five Years Ago Today, Comparison and Results of Entrance Examinations to High School by Louis J. Fish, Educational Statistician, Boston Public Schools. Pamphlet. Pages ix + 29. 13x20.5 cm. 1930. World Book Company, Yonkers-on-Hudson, New York. Price 20 cents.

Standard Service Algebra Work-Book by F. B. Knight, College of Education, University of Iowa, Iowa City, Iowa; G. M. Ruch, College of Education, University of California, Berkeley, California, and H. W. McCulloch, Superintendent of School, Chasworth, Illinois. Paper. 20.5x28 cm. 1930. Pupil's Edition, 80 pages, 44 cents. Teacher's Edition, 56 cents. Scott Foresman & Company, 623 South Wabash Avenue, Chicago, Illinois.

Geometry Workbook by H. B. Kingsbury, Chairman, Department of Mathematics, West Division High School, Milwaukee, Wisconsin, and R. R. Wallace, Instructor in Mathematics, Calumet High School, Chicago, Illinois. Paper. 164 pages, 88 tests. 21.5x28 cm. 1930. The Bruce Publishing Company, 354-364 Milwaukee Street, Milwaukee, Wisconsin. Price 76 cents.

College Biology by Henry R. Barrows, Associate Professor of Biology in New York University. Cloth. Pages xv + 414. 14x22 cm. 1930. Richard R. Smith, Inc., 12 East 41st Street, New York.

Laboratory Instruction in the Field of Inorganic Chemistry by Victor Herbert Noll, Educational Specialist, National Survey of Secondary Education. Cloth. Pages xix + 164. 14.5x23 cm. 1930. The University of Minnesota Press, Minneapolis, Minn. Price $2.00.

Introduction to Higher Geometry by William C. Graustein, Associate Professor of Mathematics in Harvard University. Cloth. Pages xv + 486. 13.5x21.5 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price $4.50.

Plans and Spherical Trigonometry by Leonard M. Passano, Associate Professor of Mathematics, Massachusetts Institute of Technology. Revised Edition. Cloth. Pages xvii + 155 + xx + 142. 12x19.5 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price $2.10.

Plane Trigonometry and Logarithms by Thomas Marshall Simpson, Head of the Department of Mathematics, University of Florida. Cloth. Pages viii + 174 + xvi + 111. 12.5x18.5 cm. 1930. The John C. Winston Co., 1006-1016 Arch Street, Philadelphia, Pa. Price $1.52.

Instructional Tests and Chapter Tests for A First Course in Algebra by Leonard D. Haertter, Head of the Department of Mathematics, John Burroughs School, St. Louis, Missouri. Paper. Pages iv + 159. 21x27 cm. 1930. The John C. Winston Co., 1006-1016 Arch Street, Philadelphia, Pa. Price 56 cents.

Teacher's Manual with Answers for Instructional Tests and Capter Tests in a First Course in Algebra by Leonard D. Haertter, Head of the Department of Mathematics, John Burroughs School, St. Louis, Missouri. Paper. 38 pages. 13x19 cm. 1930. The John C. Winston Co., 1006-1016 Arch Street, Philadelphia, Pa. Price 20 cents.

Burton Holmes Travel Stories, "China" by Eunice Tietjens. Cloth. Pages vii + 408. 13x19 cm. 1930. Wheeler Publishing Company, 2831-33-35 South Park Way, Chicago, Illinois. Price $1.28.

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Volume II: The vegetation of Long Island. Part I. The vegetation of Montauk, etc. By Norman Taylor. Pub. 1923. 108 pp. Price, $1.00.
Volume III: The vegetation of Mt. Desert Island, Maine, and its environment. By Barrington Moore and Norman Taylor. 151 pp., 27 text-figs., vegetation map in colors. June 10, 1927. Price, $1.60.

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Problems in General Science by George W. Hunter, Lecturer in Methods of Education in Science, The Claremont College, California, and Walter G. Whitman, Department of Physical Science, State Normal School, Salem, Massachusetts. Cloth. Pages xii + 688. 13x20 cm. 1930. American Book Company, 330 East 22nd Street, Chicago, Ill.

BOOK REVIEWS.

College Chemistry Quiz Book, for Kendall's "Smith's College Chemistry" by Cecil V. King, Ph.D. Assistant Professor, Washington Square College, New York University. Last edition. pp. viii + 208. 2x14x20 cm. Several curves, diagrams and tables. Cloth. 1930. The Century Co.

This is a thorough going volume of questions of both the customary and the "new type" covering all parts of the Smith-Kendall text and equally suitable for any up to date college text of inorganic chemistry. There are many helpful suggestions in the introductory matter in regard to the best method of studying a chemistry text and in connection with the profitable use of a quiz book.

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This Quiz book should be extremely useful to the busy teacher whether in college or in high school as well as to the earnest student of chemistry. F. B. W.

An Introduction to Mathematics, With Applications To Science and Agriculture by Isaiah Leslie Miller, Professor of Mathematics, South Dakota College of Agriculture and Mechanic Arts; New York; F. S. Crofts and Company, 1930. Pp. xiii + 297.

"In preparing this book," the author states in the preface, "he has kept in mind two types of students: first, those who will never take additional work in mathematics; and second, those who will continue the work in science or agriculture for advanced degrees, and will doubtless desire to pursue additional courses in mathematics." Deploring the fact that "After some fourteen years of teaching in American colleges and universities, the author finds that the average high school graduate has not developed in himself a mathematical type of reasoning," he has written this book with the hope that it "may in some measure accomplish this purpose." Whether the author includes in this hope the two types of students whom he "has kept in mind" is not clear. One may inquire, "Why try to develop at this stage a mathematical type of reasoning for the students who will never take additional work"? As to whether the treatment and organization of the book is sufficient to create "a mathematical type of reasoning" in the case of the second type of student, who have not acquired it in the high school, but need it in the pursuit of ad-

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The book is not a text in elementary mathematical analysis which is intended by modern authors to serve as the central theme of a course in general mathematics for College Freshmen. It is a textbook of elementary algebra, intermixed with trigonometry and other miscellaneous topics. The "applications to Science" are very few, and to "Agriculture," fewer. J. S. Georges.

Outlines of Sociology by John Lewis Gillin, Professor of Sociology in the University of Wisconsin and Frank W. Blackmar, Professor of Sociology in the University of Kansas. Third Edition. Cloth. Pages x+692. 14x21.5 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York, N. Y.

According to its preface, this book "attempts as from its first appearance [in 1915] to present in terms understandable by the student and teachable by the instructor a clear analysis of society, how society has developed, the processes by which society functions, and some of the maladjustments which result from the social process."

In developing this general plan, the authors devote the three chapters of part one to the definition, problems and methods of sociology. Through the initial chapters of the second part they portray the role of language, population pressure, war, cultural achievements, physical environment, racial relations and "dynamic human urges" in social evolution; they then trace the origin and development of such fundamental institutions as the family, the state, property and religion. In part three Professors Gillin and Blackmar deal with the socialization of the individual, or the change by which he "becomes a functional part of the group," and with the socialization of society itself "from a simple, loosely organized to a highly organized group." Employing "social control" as the generic term for all the agencies which unconsciously or consciously condition and regulate these interacting processes, they gave part four to the description of certain pragmatic and idealistic phases of such methods of social control as education and government. Finally, in part five the authors discuss "social pathology," which has to do with maladjustments in social relationships like poverty and crime, and point the way to "a social reconstruction whose destiny only the future can reveal."

As is usually the case with textbooks, the uniqueness of the one under consideration lies in its form rather than its substance; for the contributions of Herbert Spencer, Lester F. Ward, Franklin H. Giddings, Charles A. Ellwood, E. A. Ross, and other leading sociologists make up much of its content. However, the logical arrangement, the lucid definitions, and the clear, simple style of the book should please the student, who will doubtless give more than a passing thought to passages like this (pages 326-327):

"To-day man may not need religion to enable him to be successful in raising crops or securing food supply, but he certainly needs a faith, which may be described as 'assurance of things hoped for' and 'a conviction of things not seen' to enable him to wax valiant in the fight against organized wrong entrenched in hoary institutions. Only such faith has made the world in which we live better than that in which our fathers lived. It alone can command the energy to bring about a social order wherein increasingly 'dwelleth righteousness.'" John L. Auble.

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The Science of Biology, by George G. Scott, Professor of Biology in the College of the City of New York. xx+633 pp. 391 figures. Thomas Y. Crowell Co., New York. Revised Edition. 1930.

A notable feature of this book is the large body of biological material which it contains. The fundamental basis for organization seems to be the belief of the author that before a student can use biological materials in understanding biological principles he must know something of plants and animals which represent the biological materials. Part I of the text, 106 pages, is devoted to a treatment of the biology of plants. The author then devotes 117 pages to the biology of animals. In Part III the author begins with the morphology and physiology of the cell and then takes up a development of the biology of the vertebrate animals including embryology, histology, and comparative anatomy. Following this, 200 pages of the book are devoted to methods and processes of reproduction, physiology, genetics, paleontology, geographical distribution, organic evolution, and the biology of man.

Appendix A gives a classification of animals and plants in condensed form, Appendix B, a diagram showing the geneological tree, Appendix C, a catalogue of master biologists, and Appendix D, an extensive glossary.

The author is consistent in his treatment of biological principles according to the type of organization adopted. Considering the large amount of material included, the treatment throughout is necessarily rather brief. Each chapter has a selected list of references which will enable the student or teacher to use additional material wherever this seems desirable. Jerome Isenbarger.

Manual of Biology, by George A. Baitsell, Professor of Biology, Yale University. xiv+369 pp. The Macmillan Company, New York. Fourth Edition, 1930.

Part I which includes 220 pages of the book provides just about what one would want to give orally to supplement the directions for the laboratory work. The laboratory work is provided as a fundamental basis for the course in general biology. The emphasis is placed on morphological considerations. In general, preserved materials are used. The emphasis is laid on the organism as a unit of study rather than on a particular organ system. Each sheet of directions provides material, in general, for a single laboratory period. Since the descriptive material is separate from the laboratory directions, the latter are clear, definite, and strictly to the point. This feature adds to the value of the manual as a usable outline for laboratory work. Jerome Isenbarger.

Bacteriology, by Estelle D. Buchanan and Robert Earle Buchanan, Iowa State College. xvi+532 pp. 243 figures. The Macmillan Company, New York. Third Edition, 1930.

This book is suitable as a reference work in general biology and as a text in college or normal school classes in general bacteriology. Section I takes up the morphology, classification, and distribution of microorganisms; Section II, the cultivation and observation of microorganisms; Sections III and IV deal with the physiology of microorganisms and the effect on their environment, and Section V, on microorganisms and health takes up the pathogenic forms. This last section includes the relation of these forms to contamination of air, water and milk, and other foods. The appendix contains a key to common molds.

While some scientific background is desirable, with this book a course suited to the needs of students in general could be developed.

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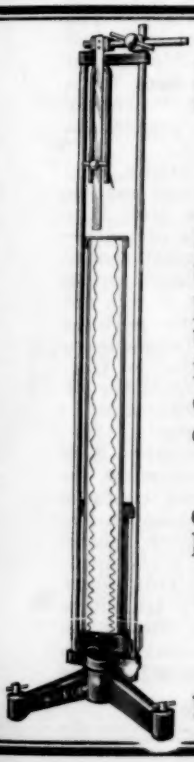

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Science in the Service of Health, by Elliot R. Downing, School of Education of the University of Chicago. 320 pp., 118 figures. Longmans, Green and Company, Chicago. 1930.

Here is a book thoroughly scientific in its treatment, yet suitable for the use of pupils in the junior high school. The background is historical. It meets a distinctly felt want in that it furnishes a means of developing an appreciation of the scientific attitude as shown by the work of the pioneers and the later outstanding men of science. The author has taken interesting details in the lives of men like Pasteur, Koch, Metchnikoff and Gorgas and has woven together fascinating stories of discovery in the field of preventive medicine.

The first part develops a discussion of the germ nature of disease, while the latter part of the book treats of the law of conservation of energy as it applies to the human machine. The final chapter of the book takes up such modern discoveries as the control of rickets, scurvy, beri-beri, together with a discussion of the subject of hormones. An appendix describes twenty-nine demonstrations suitable for use in connection with the material of the text.

The book should find wide use in general science classes and in biology classes. Jerome Isenbarger.

Elementary Theory of Finite Groups, by Louis Clark Mathewson, Assistant Professor of Mathematics in Dartmouth College. Cloth. Pages x+165, 14x20 cm. 1930. Houghton Mifflin Company, Boston. Price $2.50.

In the American Report of the International Commission on the Teaching of Mathematics, Committee No. 5, 1912, page 13, it is stated that the teachers of elemenetary and secondary mathematics should know "some group theory." Thus far it has been somewhat difficult for many of these teachers to attain this ideal stage of advancement in theoretical mathematics in view of the fact that the textbooks on this subject in English were not sufficiently elementary. The present little volume is so simply and clearly written that it is well adapted to those who desire to obtain some knowledge of this subject without the aid of a teacher. It is also suitable as a textbook for a first brief course, and its numerous references to supplementary topics and to their more complete expositions make it possible to use it also as a textbook for a somewhat extended course.

It appeared under the editorship of Professor J. W. Young, who has made an extensive study of the teaching of secondary mathematics and who says in his preface, among other things, that "the idea of a group is one of those truly fundamental concepts of mathematics with which every serious student of the subject must sooner or later make himself familiar. Although implicit in almost every part of mathematics from the earliest times to the present, it was not specifically formulated until relative recent times. This perhaps accounts for the fact that hitherto there has been no elementary textbook on this subject in English." It may be added that in German the books by Netto entitled *Gruppen und Substitutionentheorie*, 1908, and by Baumgartner entitled *Gruppentheorie*, 1921, aim to serve the same general purpose as the present little volume.

While much had to be omitted in such a brief presentation it is interesting to note that Professor Mathewson included some of the most recent elementery developments and hence his book contains theorems which do not appear in any of the other textbooks on the subject. In a few cases these theorems are perhaps more special than necessary. In particular, the theorems relating to k-ply transitive abelian groups near the bottom of page 44 although true seems somewhat awkward since it is so easy to see that every transitive abelian group is regular and hence simply transitive. A similar remark applies to exercise 2 on page 48. The mature student of this subject might also prefer to omit the words "of degree n" in the

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statement of Jordan's Theorem on page 32. The book is, however, intended for beginners in this subject and these will doubtless sometimes find it helpful to confine their attention to the special cases which are also provided by numerous well graded exercises.

In accord with a growing tendency the special monomial linear substitution groups in which the coefficients are all equal to unity are here called premutation groups. If the book had been published twenty-five years earlier this would probably not have been done since these groups are called substitution groups in both of the large mathematical encyclepedias. This is also true as regards the first editions of Pascal's *Repertorium* and Burnside's *Theory of Groups*, while in the second editions of these two popular works they are called permutation groups. Professor Mathewson seems therefore to have acted wisely in adopting the latter term even if it is somewhat misleading in view of the fact that it is used with a different meaning in elementary mathematics. It is perhaps of some interest to add that 33 different authors are noted in the Index. Their nationalities are as follows: 9 American, 9 German, 7 French, 3 English, 3 Norwegian, 1 Italian, and 1 Swiss. Naturally works in English are favored in references. G. A. Miller.

Differential Geometry of Three Dimensions, by C E. Weatherburn, M. A., D. Sc Professor of Mathematics in the University of Western Australia. Vol. II. Cloth. pages xii+239. 13.5×22 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price $4.25.

This volume continues the discussion of Differential Geometry along lines which are a natural extension of those followed in the first volume which was published in 1927. Quite a good deal of this volume is devoted to topics which have been developed by the author in recent years. Vector methods are employed throughout. In the first volume we find an introduction to Vector notation and formulas. For one who is not familiar with Vector methods it is advisable to read a more extended treatment such as the Author's Elementary Vector Analysis, G. Bell and Sons, London. J. M. Kinney.

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